Necanicum River Watershed Assessment

E & S Environmental Chemistry, Inc.

and

Necanicum River Watershed Council

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NECANICUM RIVER WATERSHED ASSESSMENT

Final Report

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

BLM	Bureau of Land Management
C-CAP	Coastal Change Analysis Program
CHT	channel habitat type
CLAMS	Coastal Landscape Analysis and Modeling Study
CREST	Columbia River Estuary Study Taskforce
DBH	diameter at breast height.
DEM	digital elevation model
DLG	digital line graph
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCB	fecal coliform bacteria
GEN	general permit
GIS	geographic information system
GPS	global positioning system
LWD	large woody debris
NMFS	National Marine Fisheries Service
NOAA	National Aeronotic and Space Administration
NPDES	National Pollutant Discharge Elimination System
NWI	National Wetlands Inventory
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OPSW	Oregon Plan for Salmon and Watersheds
OWEB	Oregon Watershed Enhancement Board
OWQI	Oregon Water Quality Index
OWRD	Oregon Water Resources Department
POD	point of diversion
RM	river mile
SSCGIS	State Service Center for GIS
TBNEP	Tillamook Bay National Estuary Project

TIN	total inorganic nitrogen concentration
TMDL	total maximum daily load
TSS	total suspended solids
U.S. EPA	U.S. Environmental Protection Agency
USDA	U.S. Department of Agriculture
USDAFS	USDA Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WPCF	Water Pollution Control Facility
WPN	Watershed Professionals Network

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EXECUTIVE SUMMARY

1. Introduction

In this watershed assessment, we have summarized current conditions and data gaps within the Necanicum River watershed to help to identify how current and past resource management is impacting aquatic resources. This background information can then be used to create a decision-making framework for identifying restoration activities that will improve water quality and aquatic habitats. Following is a summary of key findings and data gaps from the primary components of this watershed assessment, including fisheries, aquatic and riparian habitat, hydrology, water use, sediment sources, and water quality.

2 Important Fisheries

The Oregon Watershed Enhancement Board (OWEB) assessment method used in preparing this watershed assessment focuses strongly on watershed processes that affect salmonids and their associated habitats. Understanding the current condition of salmonid populations in the watershed is vital to identifying the effects of the spatial and temporal distribution of key habitat areas. Additionally, salmonids are often used as indicator species under the assumption that they are the most sensitive species in a stream network (WPN 1999, Bottom et al. 1998, Tuchmann et al. 1996). Habitat conditions that are good for salmonids generally reflect good habitat conditions for other species of aquatic biota.

Anadromous salmonid species known to occur in the Necanicum River include chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and sea-run cutthroat trout (*O. clarkii*). The chinook salmon were introduced, whereas the other species are native to this drainage. Although details of their life history and habitat requirements differ substantially, all spawn in fresh water, migrate through the estuary, and rear for varying lengths of time in the ocean before returning to their natal streams to complete their life cycle. Resident cutthroat trout and Pacific lamprey (*Entosphenous tridentatus*) are also present in the Necanicum River.

The National Marine Fisheries Service (NMFS) has listed coho salmon as threatened as required by the Endangered Species Act. Coastal cutthroat and steelhead are candidates for listing. Listing for chum and chinook was not warranted as determined by NMFS. Listing occurs for an entire Evolutionarily Significant Unit (ESU) which is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

Coho salmon populations along the entire Oregon coast are now considered depressed. Coho use nearly all of the Necanicum River watershed as habitat, including all of the subwatersheds, but the population is very low. Numbers of adult coho (mostly age 3) escaping to the spawning grounds have been indexed using the peak count method, which is based on repeated counts on the spawning grounds. Peak count surveys were conducted by the Oregon Department of Fish and Wildlife (ODFW) in the Necanicum River from 1981 through 2001. Counts have been low and variable since 1983, and all-time lows were reached in 1997. ODFW estimated coast-side coho spawner abundance in 1999. The Necanicum River, plus Ecola Creek and other mid-size ocean tributaries, only accounted for about eight percent of the coho spawners in the north coast region during that year.

A combination of factors, including rearing and spawning habitat degradation, reduction in summer streamflow, passage restriction impacts at dams, decrease in ocean productivity, excessive fishing, and impacts caused by hatchery programs, have been implicated in most of the declines and extinctions of coho salmon populations in Oregon. In coastal rivers and lower Columbia Basin tributaries, low summer flows and the loss of complex in-stream structure, winter side channels, sloughs, and shade have been identified as predominant problems. Timber harvest in the coastal temperate rain forest belt has contributed to winter habitat loss, particularly in the uplands. Logging has caused the loss of large conifers from riparian areas that would have provided long-lasting in-stream structures when they fell into streams. Siltation from logging roads, road-failures, and loss of ground cover, along with reduction of water filtering and shade due to the removal of riparian vegetation, have reduced egg and juvenile survival. Agriculture, industrialization, and urbanization have degraded coho rearing habitat in the lower river and estuary through such actions as diverting water, channelizing streams, diking off-channel and estuary areas, and releasing effluents that elevate temperatures and reduce water quality (ODFW 1995).

Agricultural and logging practices along low gradient river reaches in lower basins have greatly decreased the complexity and productivity of juvenile salmonid rearing areas. Wetlands, marshes and braided channels have been straightened, channelized, diked, drained and deforested to create croplands, pastures, and urban areas. Summer flows and water quality have also decreased and summer water temperatures have increased in these areas.

Less is known about the present status of sea-run cutthroat trout than about any of the other anadromous salmonid species in the Necanicum River watershed. Sea-run cutthroat trout, the

smallest of the anadromous salmonids present in the watershed, have not been fished commercially. This species is believed to be at very low levels in all Oregon North Coast waters. The status of the Necanicum River population is not known. It is known, however, that sea-run cutthroat trout are found in the mainstem Necanicum River and resident populations occur in some of the tributary streams above waterfall barriers.

Oregon is near the southern edge of chum salmon distribution, which may, in part, account for the large interannual variability in run sizes that have been observed in some populations over the years. Chum salmon populations have been very depressed south of the Columbia River. The Necanicum River has a sustaining population of chum salmon, but it is very small and unstable. Due to the very low counts on the spawning grounds since about 1992, concern has been growing that the chum populations throughout the North Coast of Oregon are experiencing serious problems. Chum salmon use only the lowest portions of the Necanicum River watershed, and require typical low gradient, gravel-rich, barrier-free freshwater habitats and productive estuaries. They have not been supplemented by hatchery fish.

Most coastal steelhead in Oregon are winter-run fish and summer steelhead are present only in a few large watersheds. The subspecies (*Oncorhynchus mykiss irideus*) includes a resident phenotype (rainbow trout) and an anadromous phenotype (coastal steelhead). Winter steelhead are native to the Necanicum River and are widely distributed throughout the watershed. Winter steelhead generally enter streams from November through May and spawn soon after entering freshwater.

No reliable information on the historic abundance of steelhead in the Necanicum River is available. Rough estimates of total coast-wide steelhead run size made in 1972 and 1987 were similar (Sheppard 1972, Light 1987), suggesting that overall abundance remained relatively constant during that period. The steelhead population in the Necanicum River has been judged to have been impacted by habitat deterioration, but appears to be healthy at present. Most spawning occurs in the mainstem.

Coastal steelhead abundance follows a similar cycle in all populations from Puget Sound in Washington to California, indicating that factors common to all populations influence trends. The most probable factor responsible for this cycle is ocean condition. Ocean productivity is recognized to undergo long-term cycles that include periods that are relatively favorable or unfavorable to the survival of salmonids. This cycle appears to be a natural process that is not strongly affected by management actions. The ocean productivity cycle appears to have been

unfavorable for steelhead recently, and all steelhead population abundance trends have been correspondingly low (ODFW 1995).

Steelhead and rainbow trout populations have also been affected by freshwater habitat degradation. Most coastal salmonid freshwater habitats were historically coniferous, temperate, rain forest ecosystems. Stream systems were structurally complex, with large in-stream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs. Human activities have altered these ecosystems, particularly by reducing their complexity and removing components that were essential to steelhead and rainbow trout production. Logging and road construction in the Coast Range and Cascade Mountains have had the most widespread impact on coastal steelhead, and have affected most populations.

There has been a high-intensity winter steelhead fishery in the Necanicum River, targeted on hatchery fish. Nevertheless, the Necanicum River has continued to produce viable numbers of wild or unmarked fish.

3. Aquatic and Riparian Habitats

Distribution and abundance of salmonids within the watershed varies with habitat conditions such as substrate and pool frequency as well as biological factors such as food distribution. In addition, salmonids have complex life histories and some use different portions of the watershed during different parts of their life cycle. There are also differences among salmonid species in their timing and extent of habitat utilization. The interactions of these factors in space and time make it difficult to identify the specific watershed components that most strongly affect salmonid populations. Consequently, entire watersheds must be managed to maintain fish habitats, and not just individual components.

Healthy populations of anadromous salmonids are generally associated with the following freshwater habitat characteristics:

- cool, clean, well-oxygenated water;
- unobstructed access to spawning grounds;
- clean, stable spawning gravel;
- winter refuge habitat for juveniles;
- complex stream channel structure with an appropriate mixture of riffles, pools, and glides;
- deep pools;

- stream channels with an abundant supply of large woody debris;
- abundant food supply;
- adequate summer stream flows; and
- diverse, well-established riparian community.

ODFW has conducted stream habitat surveys in approximately 19 percent of the Necanicum River watershed stream network. Habitat conditions are variable in time, however, and change in response to hydrologic factors. In particular, large flood events, such as occurred in 1996, can alter large woody debris (LWD) and sediment conditions in the watershed to a significant extent.

Stream morphology describes the physical state of the stream, including features such as channel width and depth, pool frequency, and pool area (Garono and Brophy 1999). Pools are important features for salmonids, providing refugia and feeding areas. Substrate type is also an important channel feature since salmonids use gravel beds for spawning. These gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat. For streams that were surveyed, stream morphology and substrates were compared against ODFW benchmarks to evaluate current habitat conditions. In the streams surveyed, the pool frequency for the majority of the pools fell in the moderate category, and the remainder were rated as desirable for pool frequency. The majority of the stream reaches were also in the moderate category based on the percent of area of the stream reach in pools. However, 12 percent of the surveyed streams were rated as undesirable for percent pools. In general, the depth of pools was moderate. Residual pool depth was desirable for 16 percent of all stream reaches surveyed. None of the surveyed streams had undesirable residual pool depths.

Gravel conditions in riffles demonstrated generally desirable conditions, although Bergsvik Creek and South Fork Necanicum River showed moderate conditions in all reaches surveyed.

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000, BLM 1996). LWD is more abundant in intermediate sized channels in third- and fourth-order streams than in larger streams. In fifth-order and larger streams, the channel width is generally wider

than the length of a typical piece of LWD, and therefore, LWD is not likely to remain stable in the channel.

LWD conditions in the surveyed streams were undesirable. In particular, the density of key pieces of LWD was consistently rated as undesirable. Riparian conditions uniformly demonstrated undesirable conditions, with all streams lacking sufficient densities of conifers in the riparian zones.

The potential for LWD recruitment in the Necanicum River watershed was poor. None of the riparian areas in the watershed demonstrated a high potential to contribute LWD to the stream channel. In all of the subwatersheds except Neacoxie, at least 75 percent of LWD recruitment potential was classified as low. The lack of large conifers (>24" dbh) in this watershed is likely a result of vegetation removal and historic fires along the riparian corridor.

Riparian vegetation is an important element of a healthy stream system. It provides bank stability, controls erosion, moderates water temperature, provides food for aquatic organisms and large woody debris to increase aquatic habitat diversity, filters surface runoff to reduce the amount of sediments and pollutants that enter the stream, provides wildlife habitat, dissipates flow of energy, and stores water during floods (Bischoff et al. 2000). Natural and human degradation of riparian zones diminish their ability to provide these critical ecosystem functions.

Shade conditions in the streams in the Necanicum watershed surveyed by ODFW were generally rated as desirable. Only the Neacoxie subwatershed showed a significant proportion of less-than-desirable shade conditions. Results from our air-photo analysis of stream shading yielded similar results to the stream reach surveys of ODFW. Stream shading conditions were generally high across the watershed. Shade conditions were high for at least 50 percent of the stream length in five of the seven subwatersheds. Areas not rated as high generally occurred along the mainstem of the river and in the two lower subwatersheds (Neacoxie and Seaside).

Stream channels are often blocked by natural barriers, such as waterfalls, or by human-caused barriers, especially poorly designed culverts at road crossings. This has resulted in significant loss of fish access to suitable habitat. Anadromous fish migrate upstream and downstream in search of food, habitat, shelter, spawning beds, and better water quality. Fish populations can be significantly limited if they lose access to key habitat areas.

Only 23 culverts out of a total 259 road-stream crossings have been surveyed for potential fish passage barriers by ODFW, and 69 percent of those surveyed were judged to be impassable. The Necanicum River watershed has an average stream crossing density of 3.2 stream crossings

per square mile. Stream crossing densities were highest in the South Fork and Seaside subwatersheds (4.4 and 4.2 crossings per square mile, respectively). The Upper Necanicum subwatershed contained half of the surveyed culverts in the watershed that were judged to be impassable. It should be noted, however, that only a very small percentage of the culverts in the watershed have been surveyed by ODFW.

Disconnecting the floodplain from the river can lead to reduced physical complexity and channel downcutting due to increased water velocities, resulting in deteriorated habitat conditions. Additionally, disconnection from the floodplain can lead to changes in the biotic structure of the aquatic ecosystem by limiting nutrient and organic material exchanges between the stream and floodplain. Urban development and associated attempts to control flooding have reduced the natural complexity of the river channel and separated the river from its floodplains in some places. The loss of natural floodplain function has impacted other resources with economic value, such as the fish and shellfish industries, which attracted commercial and residential development to the floodplain (Coulton et al. 1996). To some degree, hydrological modifications have probably increased streambank erosion by increasing water depth and flow velocity in the lower river (Leopold et al. 1992). In addition, the removal of large woody debris has made streambanks more vulnerable to this type of erosion process.

Wetlands contribute critical functions to watershed health, including water quality improvement, filtration, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Wetlands constitute an important landscape feature in the Necanicum River watershed. The predominant wetland types are palustrine wetlands and estuarine marshes. Palustrine wetlands are common along many of the stream corridors, especially in the Neacoxie and Seaside subwatersheds.

Wetlands play an important role in the life cycles of salmonids (Lebovitz 1992, Shreffler et al. 1992, MacDonald et al. 1988, Healey 1982, Simenstad et al. 1982). Estuarine wetlands provide holding and feeding areas for salmon smolts migrating out to the ocean. These estuarine wetlands also provide acclimation areas for smolts while they are adapting to marine environments. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate (Mitsch and Gosselink 1993). Wetlands also provide cover and a food source in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream.

Good (2000) determined that tidally-influenced wetland habitat in the Necanicum River watershed has been reduced by only about 10 percent since the mid-1880s. In contrast, 13 of the 17 largest estuaries in Oregon were estimated to have lost more than half of their original tidal wetland area. In general, the complexity of the Necanicum estuarine habitat has been reduced, however. Complex structure provided by LWD and associated pools has been removed and the connections between river channels and some portions of their floodplains have been altered. These losses are probably permanent.

Thus, the overall condition of aquatic and riparian habitats in the watershed has been changed. Habitat quality for salmonid fish and other biota has been reduced. On-going and future efforts to restore habitat quality include, in particular, replacement of culverts that have blocked fish access to important habitat, improvement of LWD and LWD recruitment potential, and livestock exclusion.

4. Hydrology

Human activities in the watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and the condition of aquatic habitats. Changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge.

Topography in the Necanicum River watershed is characterized by steep headwaters that lead quickly into low-gradient floodplains. Elevations in the watershed range from sea-level to 2,846 feet it its highest point. Precipitation ranges from about 74 inches annually in the lowlands to abut 150 inches in the highest elevations of the watershed (based on PRISM model calculations; Daly et al. 1994).

Flooding is a natural process that contributes to both the quality and impairment of local environmental conditions. Consequently, flood management attempts to reduce flood hazards and damage while protecting the beneficial effects of flooding on the natural resources of the system. River flooding tends to occur most commonly in December and January, during periods of heavy rainfall or snowmelt, or a combination of both. River flooding combined with tidal flooding can extend the flood season from November to February. The lowland valleys are the most prone to flooding during these periods.

Peak flows occur as large volumes of water move from the landscape into surface waters. The primary process that generates peak flows in streams of the Coast Range and its associated

ecoregions is rain events. The Coast Range generally develops very little snow pack. Snow pack that does develop in the coastal mountains is usually only on the highest peaks and is of short duration. Rain-on-snow events are infrequent in the Coast Range although these events have contributed to some of the major floods, including the floods of 1964 and 1996. These large floods are rare events, and we have no data to suggest that current land use practices have exacerbated the flooding effects from rain-on-snow events.

The Necanicum River watershed has an extensive floodplain area that occupies about seven percent of the watershed. There are substantial estuarine and palustrine wetlands adjacent to the mouth of the river and in the Neacoxie and Seaside subwatersheds are often inundated during flooding periods. One of the primary natural functions of the floodplain is to reduce the severity of peak flows, thereby reducing downstream impacts and flood hazards. Portions of the floodplain area in the Necanicum River watershed have been altered, reducing floodplain storage of flood waters. The impacts of these changes are expected to be minimal, however, because the floodplain wetlands are largely intact and downstream development is not spatially extensive.

Increased peak flows can have deleterious effects on aquatic habitats by increasing streambank erosion and scouring (ODFW 1997a). Furthermore, increased peak flows can cause downcutting of channels, resulting in a disconnection of the stream from the floodplain. Once a stream is disconnected from its floodplain, the downcutting can be further exacerbated by increased flow velocities as a result of channelization.

Although the largest floods are most important from a flood hazard standpoint and are frequently associated with rain-on-snow events, the effects of increases in smaller magnitude peak flows cannot be discounted from a stream channel or ecological standpoint (Naiman and Bilby 1998). High flows constitute a natural part of the stream flow regime and are largely responsible for transporting sediments and forming channels. Consequently, increases in the magnitude of moderate peak flows can lead to channel incision thorough bank building or erosion. Because forest harvest practices are common in the watershed, there may be effects of forestry on watershed hydrology other than those commonly associated with rain-on-snow events. These might include reduced evapotranspiration, increased infiltration and subsurface flow, and increased overland flow (Naiman and Bilby 1998). Such changes may result in modified peak and low flow regimes and subsequent effects on in-stream aquatic habitat quality.

Road construction associated with timber harvest and rural development has been shown to increase wintertime peak flows of small to moderate floods in Oregon Coast Range watersheds

(Harr 1983, Hicks 1990). This assessment uses a roaded area threshold of eight percent to screen for potential impacts of roads on peak flows (discharge increase >20 percent; WPN 1999). Watersheds with a greater than eight percent roaded area are considered to have a high potential for adverse hydrologic impact, four to eight percent have a moderate potential, and less than four percent have a low potential.

According to GIS calculations from the ODF fire roads coverage, the density of forest roads in all of the subwatersheds in the Necanicum River watershed were considered to have a low potential impact on hydrology. Screening for land management activities that may be affecting natural hydrologic conditions suggests that forest roads have little effect on current hydrologic regimes, but other hydrologic impacts may have occurred in response to upland management and/or development in the valley bottom. Rural residential areas generally showed moderate to high potential for peak flow enhancement, but occupy relatively little area. Their overall impact on watershed hydrology is expected to be minimal. Loss of historical floodplain acreage and land cover (such as wetlands, forested valley bottoms) have likely had minimal impacts on hydrologic conditions in the Necanicum River watershed.

5. Water Use

Water that is withdrawn from the stream has the potential to affect in-stream habitats by dewatering that stream. Dewatering a stream refers to the permanent removal of water from the stream channel, thus lowering the natural in-stream flows. In-stream water rights were established by the Oregon Water Resources Department for the protection of fisheries, aquatic life, and pollution abatement; however, many remain junior to most other water rights.

The largest amount of water appropriated in the Necanicum River watershed is for municipal and domestic use by the City of Seaside (17.65 cfs). Most of this water is appropriated from the South Fork Necanicum River.

Based on current water availability model outputs, there appears to be significant concern for dewatering in the Necanicum River watershed. Three of the subwatersheds consistently demonstrated water loss greater than 20 percent of the predicted in-stream flows. In the South Fork Necanicum River, dewatering potential exceeded 100 percent of flows one out of every two years. Consequently, it is likely that water withdrawals from the Necanicum River and its tributaries are having a large impact on current in-stream flows. Any time water is appropriated for out-of-stream use, there is a potential for some effects on the in-stream habitats to occur

during periods of low flow. It is our recommendation that in-stream water rights continue to be protected and in-stream flows monitored during low flow conditions.

The amount of water that has been appropriated for fish and wildlife represents about one-tenth of the total water rights for the watershed. Assuming that the in-stream water right for fish and wildlife is a good indicator of the amount of water required to provide adequate habitat conditions for salmonids, there appears to be a potential for low flow conditions to have deleterious effects on local salmonid populations. Any out-of-stream water use during low flow situations would be expected to exacerbate habitat problems. In-stream flow requirements for salmonids need to be further evaluated to determine actual impacts of surface water withdrawals on salmonid populations. Protection of in-stream flow for salmonid habitat is needed in the Necanicum River watershed.

6. Sediment Sources

Erosion is a natural watershed process in the Oregon Coast Range. The bedrock geology of much of the Oregon Coast is composed of weak, highly erosive rock types. However, most experts agree that land use practices have increased the rate of erosion in many coastal watersheds (WPN 1999, Naiman and Bilby 1998). High levels of sediment in rivers and streams are associated with loss of agricultural lands and filling of the estuaries. Sediment is also negatively impacting many aquatic organisms. Sediment input to the stream system is highly episodic, with the majority of sediment deposition into the stream system occurring during large storm events. Understanding the role of erosion and its interaction with other watershed processes is critical to maintaining a healthy ecosystem.

Upland processes that deliver sediment to the stream system include landslides and surface erosion. In lowland streams and rivers, erosion occurs primarily as streambank erosion, which often causes significant losses of riparian agricultural land. Wildfires in the uplands alter soil conditions, setting the stage for increased rates of erosion. In this watershed, slope instability, road instability, rural road runoff, and streambank erosion are significant sources of sediment. Shallow landslides and deep-seated slumps are common in the Oregon Coast Range. Streamside landslides and slumps are major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Forest and rural residential roads are a common feature of this watershed, and some of the forest roads are present on steep slopes. Washouts from roads contribute sediment to streams, and sometimes initiate debris flows in the upper watershed. The

density of roads, especially unpaved gravel and dirt roads, indicates some potential for sediment contribution to the stream network.

Agricultural and pasture land runoff, as well as the history of fire in the region, are also contributing factors. However, because agricultural and pastoral lands occupy less than one percent of this watershed and are mostly located at the lower elevations of the watershed, their contribution to sediment is low. Urban runoff is also not expected to be a major contributor of sediment in this watershed. Developed lands (urban and rural residential) occupy about six percent of the Necanicum River watershed.

Under natural conditions, geology, topography, and climate interact to initiate landslides. With human intervention, natural conditions may be modified in ways that increase the likelihood of landslides occurring. Road-building often creates cuts and fills. In a slide-prone landscape, road-cuts may undercut slopes and concentrate runoff along roads, and road-fills on steep slopes may give way, initiating a landslide (NRC 1996). Vegetation removal, such as by logging or wildfire, may also increase the likelihood of landslides and consequent debris flows. In the short term, a debris flow can scour a channel or remove beneficial prey (benthic macroinvertebrates) and channel structures. Over the long term, these events deliver woody debris, organic matter, and gravel that could result in the reestablishment of productive aquatic habitat and provide an important reset mechanism to the stream ecosystem.

Landslide inventory data for the Necanicum River watershed were not available for analysis and inclusion in this assessment. Based on topography, studies conducted in other coastal areas, and an evaluation of potential debris flow hazard zones, landslide frequency in the Necanicum River watershed is probably moderate. Specific locations of landslide activity are unknown, although landslides and debris flows probably contribute the majority of the sediment in the watershed.

Human uses of the lowlands have affected the rate and character of lowland sedimentation through changes in flooding frequency and size, and by the alteration of floodplains and wetlands. In addition, channel modification, removal of LWD, and streamside grazing have increased streambank erosion. These changes have in turn affected the quantity and quality of riparian and aquatic habitat in the lowlands.

Sediment in the rivers and streams of the Necanicum River watershed is an issue of concern. The combination of the wet climate, steep slopes in the uplands, and erosive soils results in naturally high levels of sediment in coastal rivers and streams. The historic wildfires in the

watershed, as well as resource management practices over the past century, are associated with an additional increase in sediment levels. High levels of sediment in the streams may have contributed to increased rates of sedimentation in the estuary. Additionally, high sediment levels are associated with the declining health of salmonid populations. While naturally occurring sources of sediment in the watershed may be uncontrollable (and perhaps to some degree beneficial), the additional sediment contributed by human activity can in some cases cause habitat degradation.

Roads are the primary source of sediment related to human activity in the Necanicum watershed. Contribution of sediment from roads is attributed to two processes: landslides originating from roads, and road runoff. Landslides coming from roads generally produce the largest proportion of road-associated sediment. The high density of stream-crossing culverts on sidecast dirt and gravel roads indicates that road-associated landslides are of concern in the Necanicum River watershed. However, few roads within the watershed are both in close proximity to a stream and on a slope greater than 50 percent. Road-related sediment contribution to streams is therefore not expected to be a substantial problem. Cooperation with private landowners to identify and improve sediment sources on private roads will help to mitigate the impact of sediment in the watershed.

Lastly, streambank erosion is a significant concern in the lower portions of the Necanicum River watershed. While the overall contribution of sediment from streambank erosion is probably less than other sources, erosion from the streambank is associated with a lack of riparian shade and consequent effects on water temperature. Restoration of riparian vegetation and prevention of livestock grazing near streambanks will lessen sediment contribution from streambank erosion.

7. Water Quality

The water quality assessment proceeds in steps. The first step is to identify uses of the water that are sensitive to adverse changes in water quality and identify potential sources of pollution in the watershed. The second step establishes the evaluation criteria. The third step examines the existing water quality data in light of the evaluation criteria. Conclusions can then be made about the presence of obvious water quality problems in the watershed, and whether or not additional studies are necessary. The ODEQ has developed the Oregon Water Quality Index (OWQI) as a water quality benchmark that is keyed to indicator sites monitored regularly by ODEQ. The

OWQI integrates measurements of eight selected water quality parameters (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia+nitrate nitrogen, total phosphates, total solids, fecal coliform bacteria) into a single index value that ranges from 10 (the worst) to 100 (the best). Land use, geology, hydrology, and water quality vary widely throughout the North Coast region. Comparing minimum seasonal Oregon Water Quality Index (OWQI) values, water quality in the Necanicum River ranges from good to excellent according to OWQI, and generally as good as, or better than, water quality in other nearby rivers. Water quality data are collected by the ODEQ for the Necanicum River at Seaside as part of their ambient water quality network. In addition, STORET contains water quality monitoring data for 16 sites in the watershed that have been sampled more than once since 1966.

Major tributaries were sampled for temperature during the summers of 2000 and 2001 by the watershed council. Temperature data have been statistically processed to yield the 7-day average of the daily maximum temperatures (commonly referred to the *7-day statistic*). These 7-day statistics are used to specify if the sampled stream temperatures violate State water quality standards. Based on these data, none of the tributaries appear to be temperature-limited for salmonid rearing and growth, but may be moderately impaired for salmonid spawning and incubation. In summer months, the various tributaries reach maximum 7-day average stream temperatures in the range of about 14° to 17° C.

Of the 119 available dissolved oxygen measurements, 15 (12.6 percent) were below 8.0 mg/L, and 77 (64.7 percent) were below 11.0 mg/L. These data suggest that at least portions of the Necanicum River may be impaired with respect to dissolved oxygen to support salmonid spawning and incubation.

Available monitoring data indicated that total phosphorus concentration in the Necanicum River was above the screening criterion of 0.05 mg/L in 43 percent of the measured samples. These data suggest that the Necanicum River may be moderately impaired with respect to phosphorus. However, based on recent studies of the Wilson River, it is possible that much of the phosphorus in streamwater in the Necanicum River watershed may be associated with suspended solids derived from upland erosion and may not necessarily contribute to algal growth in the aquatic ecosystem.

Available monitoring data suggest that nitrate concentrations have increased in the Necanicum River since the 1960s. The cause of such an increase in nitrate cannot be determined from the available data. It is possible that nitrogen fixation in large alder stands in the watershed

may be contributing to higher nitrogen concentration in the river. The available data suggest, however, that the Necanicum River water quality may be moderately impaired with respect to nitrogen.

The Necanicum River is on the 1998 ODEQ 303(d) list of water quality impaired water bodies for bacteria from the mouth of the headwaters. Additional sampling during storm events is needed to more fully evaluate bacterial contamination.

Only 1 of 142 measurements exceeded the turbidity evaluation criterion of 50 NTU. This suggests that the Necanicum River is not impaired with respect to turbidity. However, turbidity is generally associated with high discharge conditions, and the discharge levels at the time of sample collection are not known for the available monitoring data. Additional sampling during storm events is needed to more fully evaluate turbidity.

At the screening level of this assessment, water quality in the major streams of the Necanicum River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, nitrogen, total phosphorus, and bacteria. Dissolved oxygen may also be a problem with respect to salmonid spawning and incubation. There is no reason to suspect that the river suffers from impairment with respect to pH, turbidity, or trace metals. There are not sufficient data to make a preliminary judgement with respect to organic contaminants. It should be noted, however, that available water quality data are not adequate for water quality characterization in this watershed, especially with respect to spatial variability and the response of parameters that tend to be episodic in nature, such as bacteria, turbidity, and total phosphorus.

CHAPTER 1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this watershed assessment is to inventory and characterize watershed conditions of the Necanicum River watershed and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. This assessment was conducted by reviewing and synthesizing existing data sets and some new data collected by the watershed council, following the guidelines outlined in the Oregon Watershed Enhancement Board (OWEB) watershed assessment manual (WPN 1999).

It is important to note that many watershed processes cannot be characterized as either good or bad. Rather, these processes must be evaluated by their likely impact on valued resources such as salmonid habitat or water quantity and quality. By summarizing the existing conditions of the Necanicum River watershed we hope to help natural resource managers and watershed council members to better understand the complex interactions that occur within the watershed. It is through this understanding that watersheds can be managed to protect the natural resources valued by local and national communities.

This assessment is diagnostic. It does not prescribe actions for specific stream segments. The intent of this assessment is to provide a decision-making framework for identifying areas of the watershed in need of protection and restoration. The assessment is conducted on a watershed level, recognizing that all parts of a watershed function as a whole and that alteration or loss of one watershed process or component can affect many other processes and components in the watershed.

1.1.1 The Decision Making Framework

A major product of the OWEB watershed assessment method is a set of wall-size maps (housed by the watershed council) to be used for selecting appropriate sites for on-the-ground restoration. The maps are organized so that they can be directly related to the U.S. Geological Survey (USGS) 1:24,000 quad sheets. Included on the maps are outlines of the quad sheet boundaries, township section, and range lines. These maps allow the information to be compiled by section (Public Land Survey System) and located. By compiling stream information by section, information can be used to make intelligent, science-based decisions regarding where restoration actions are most likely to be successful. All sites selected from the maps for restoration should be field checked before restoration or protection actions are implemented.

Wall-size maps provided to the watershed council include anadromous fish distribution, channel habitat type, riparian conditions, and possible fish barrier locations. Additional data are provided in a digital format to the watershed council. This document supplements and expands on the information contained in the maps and the digital database. The maps in this document, by virtue of their scale, are only intended to provide summary visual representation of the data used in this assessment. They are not meant to provide site-specific information. The wall size maps and digital data should be used for identification of potential on-the-ground restoration opportunities.

1.1.2 Geographic Information Systems Data Used in this Assessment

Geographic Information Systems (GIS) are widely used to store and analyze spatial environmental data for the purposes of evaluating watershed condition and guiding appropriate restoration activities. GIS data are only as accurate as their scale and source data. GIS data must be critically reviewed, and in many cases ground-truthed, to assure an accurate representation of on-the-ground conditions in a watershed. Key GIS data sets were evaluated for confidence in positional accuracy and in representing actual watershed conditions.

Major GIS data that were used in the development of this assessment are listed in Table 1.1. Following is a description of each of the data layers used in developing this watershed assessment.

<u>Streams (1:24,000):</u> Stream coverages were obtained from the State Service Center for GIS (SSCGIS) and are a part of the Baseline 97 data set. Streams were digitized from the 1:24,000 USGS quads. A visual check of the stream coverage demonstrated that they match the USGS quadrangles, although the positions of the streams were often slightly different from the streams on the aerial photos.

<u>Channel Habitat Types (CHTs; 1:24,000):</u> Stream channels were divided into distinct segments, based on topographic and geomorphic factors. The 1:24,000 stream coverage was attributed with gradient, side slope constraint, and stream-order, and classified into channel habitat type classes according to the protocol outlined in the OWEB manual (WPN 1999).

Table 1.1 Primary GIS data used in developing this watershed assessment.

Coverage	Scale	Source	Notes
Streams	1:24,000	SSCGIS	
Channel Habitat Types	1:24,000	E&S	Streams attributed by E&S
Land use	1:24,000	E&S; CREST; C-CAP; SSCGIS	Created by E&S by combining data
Vegetation	30 meter	CLAMS	CLAMS 1995 LANDSAT
Aerial Photos	1 meter	Clatsop County Planning Office	MAY, JUNE, JULY 1994 natural color
Watershed Boundaries	1:24,000	SSCGIS	Created for the councils by SSCGIS
Roads	1:100,000	ODF	Updated digital line graphs (DLGs); Ad Hoc
Digital Elevation Models	10 meter	SSCGIS	
Riparian Vegetation	1:24,000	E&S	Attributed 1:24,000 streams from aerial photo interpretation
Riparian Shade	1:24,000	E&S	Attributed 1:24,000 streams from aerial photo interpretation
Salmonid Distribution	1:100,000	ODFW	Field Biologists
ODFW Habitat Surveys	1:100,000	ODFW	Attributed 1:100,000 streams from field surveys
Debris Flow Potential		ODF	
Points of Diversion	1:24,000	OWRD	Currently being updated

Land Use (1:24,000): The land use map was created using primarily three coverages: zoning from the Columbia River Estuary Study Taskforce (CREST; 1:24,000), ownership (1:24,000), and a 1992 LANDSAT image obtained from CREST and the Coastal Change Analysis Program (C-CAP). The three coverages were combined and land use was delineated based on these three attributes. For example, if the LANDSAT image classified the land as bare, and zoning was Exclusive Farm Use, then this polygon was attributed as agriculture. Additionally, if the LANDSAT

image classified the land as developed and the zoning was in the urban growth boundary, this polygon was attributed as developed. The forest lands were delineated by ownership, and categorized as Private Industrial Forest, Private Non-Industrial Forest, or State Forest (for those areas where ownership was not specifically identified). All areas characterized as wetlands by the LANDSAT scene were maintained in the coverage and were compared with National Wetlands Inventory (NWI) wetlands.

Zoning: There are no metadata (data describing the coverage) associated with these data. This coverage was provided by CREST and is believed to be the most up to date zoning information for Clatsop County at the time of this assessment. The coverage is currently being updated.

Ownership: Ownership was characterized by Oregon State University (OSU) using the 1991 Atterbury Ownership maps. This coverage does not include land sales since 1991. It is our assumption that land sales in the North Coast watersheds have primarily been sales that kept the land in the same category.

C-CAP LANDSAT image: These data consist of one LANDSAT Thematic Mapper scene which was analyzed according to the C-CAP protocol to determine land cover. C-CAP inventories coastal submersed habitats, wetland habitats, and adjacent uplands through analysis of satellite imagery (primarily LANDSAT Thematic Mapper), aerial photography, and field data. These are interpreted, categorized, and integrated with other spatial data in a geographic information system.

<u>Vegetation:</u> The vegetation characterization was completed using a 1995 LANDSAT image from the Coastal Landscape Analysis and Modeling Study (CLAMS) being conducted jointly by the OSU, USDAFS Pacific Northwest Research Station, and Oregon Department of Forestry (ODF). The LANDSAT scene was characterized into broadleaf, mixed, and conifer-dominated stands, which were further delineated into four categories based on conifer size (small, medium, large and very large).

<u>Aerial Photos:</u> Aerial photos were obtained from the Clatsop County Planning Office and were taken in May, June, and July of 1994 by Spenser Gross. Aerial photos were natural color, digital ortho photos with a 1 m pixel size.

Watershed Boundaries (1:24,000): Watershed boundaries were digitized and corrected by the SSCGIS.

Roads (1:100,000): Roads data were obtained from the ODF. ODF maintains fire road information for the entire state of Oregon. These road coverages were developed using the USGS DLGs as a base and then updated on an ad-hoc basis determined by data availability. The extent of updates that have been included in the roads coverage in these watersheds is unclear. However, a visual check of the data with the aerial photos demonstrated that the data were fairly accurate. A more detailed evaluation is needed to evaluate how well this data set represents 'real-world' conditions.

Digital Elevation Models (DEMs; 10 m): The 10 m-resolution DEMs were obtained from the SSCGIS. Ten meter resolution refers to the cell size attributed with elevation data. Cell sizes in this coverage are 10 m by 10 m, or approximately 1,000 sq. ft. DEMs were mosaiced and sinks were filled.

Riparian Vegetation and Shade: The 1:24,000 stream coverage was attributed from aerial photo interpretation (see Aerial Photos above). Attributes include vegetation class and shade. Metadata have been provided with the digital data.

Salmonid Distribution (1:100,000): Salmonid distribution coverages were obtained from the Oregon Department of Fish and Wildlife (ODFW). ODFW mapped current salmonid distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*http://www.dfw.state.or.us*).

ODFW Fish Habitat Surveys (1:100,000): Field surveys of stream channel conditions by ODFW were attributed onto 1:100,000 scale stream layers. Two layers exist, including habitat units and reach level data. Reach level data generalize habitat unit data to give an overview of current habitat conditions. Reach level data can be used as a reference point for later comparative work or for the analysis of overall stream conditions. Habitat data include all of the unit data for the entire survey and provide a representation of the condition of the stream at the time of survey. These conditions change annually since streams are dynamic systems.

<u>National Wetlands Inventory</u> <u>(1:24,000):</u> The primary source for wetland information used in this assessment was the NWI maps created by the U.S. Fish and Wildlife Service (USFWS). Very few of the NWI quads had been digitized by USFWS for the Necanicum River watershed, so information was generally derived from hard copy NWI maps. It is important to note that NWI wetland maps are based on aerial photo interpretation and not on ground-based inventories of wetlands. On-the-ground inventories of wetlands often find extensive wetlands that are not included on the NWI maps.

<u>Debris Flow Potential:</u> The ODF created debris flow hazard maps based on underlying bedrock geology, slope steepness, historical landslide information, and stream channel confinement where applicable. Slope data were generated from 1:24,000 DEMs. These maps were created to show areas where on-the-ground investigation is prudent before conducting land management and development activities that could be impacted by debris flows. Further information was provided with the digital data.

<u>Points of Diversion (1:24,000):</u> Points of diversion were mapped by the Oregon Water Resources Department (OWRD) by digitizing individual water rights into a township coverage. Only permitted and certificated rights were digitized. All water rights should be up-to-date and maintained by OWRD. Links from points of diversion to actual water rights were found to be missing in this assessment, which was probably due to the database needing to be updated (Bob Harmon, pers. comm.).

1.1.3 Data Confidence

GIS data vary in how well they represent actual on-the-ground conditions. Several of the data sets used to develop this assessment need to be evaluated and compared to on-the-ground conditions before restoration actions are taken or final conclusions are made about ecosystem processes. Data sets in need of further evaluation have been listed in the Recommendations section of this document. A few of these will be discussed here because they have characteristics that must be kept in mind while reading this document.

<u>Land Use and Wetlands</u>

The land use was refined from a LANDSAT scene, zoning, NWI and ownership (see section 1.8), which have all been field verified. NWI data were not available digitally for the entire area

and so were used only in the areas of digital coverage. Other wetland data were derived from the LANDSAT scene. NWI data are much more accurate because they are derived from aerial photo interpretation. Consequently, some areas that have been classified as wetlands are really agricultural fields. As NWI data become more readily available in digital format, the land use coverage should be updated. All land use categories should be field verified before restoration actions begin. We believe that this land use coverage is a fair representation of land use in the watershed for the scale of this assessment. It is most likely an under-representation of wetland areas.

Roads

The roads coverage is a key coverage used to evaluate potential sediment sources and changes in watershed hydrology associated with road construction. However, it is not clear that road coverage accurately represents on-the-ground conditions in this watershed. The road coverage was developed from the 1:100,000 USGS digital line graphs. These coverages were then updated on an ad-hoc basis from aerial photos and other sources of information that became available. A visual comparison of the data to aerial photos found the roads coverage to be fairly accurately. Although this coverage represents the best available data for roads, the data are suspect. A study could be developed to determine the accuracy of the roads data.

Channel Habitat Types

Channel habitat types (CHTs) were determined for this assessment using GIS. Streams were divided into habitat types based on stream size, gradient, valley width, and ecoregion, according to OWEB protocols (WPN 1999). Minimum length of a habit type was 1,000 ft. CHTs provide an overall indication of the quality and distribution of various stream and associated riparian habitats throughout the watershed. Additional field-based assessment will be required for site-specific restoration activities.

Riparian Vegetation and Shade

Riparian conditions need to be further evaluated and ground-truthed before restoration actions occur. A visual comparison of field checks to the aerial photo interpretations found the data to be fairly consistent. After site selection using the GIS data, any stream reach identified

for further action should be field-checked for actual on-the-ground conditions. A more rigorous analysis of the GIS data could also be performed.

Overall, the confidence in the GIS data is moderate to good for watershed-level assessment purposes. Collection of field data is always recommended; however, field data collection is expensive, time consuming and often unfeasible for very large areas. Time can be saved by using the GIS data to select possible sites for restoration. Field verification can then define the exact conditions present at these potential restoration sites. Used in this way, the GIS data can provide an extremely efficient decision-making framework to guide restoration activities.

1.2 Setting

Like most Pacific Northwest estuaries, the Necanicum River estuary is part of a coastal, temperate, rainforest ecosystem. The estuary is bordered by the city of Seaside, but surrounded by rich forests associated with the Oregon Coast Range. With mean annual precipitation around 80 inches (200 cm) per year in the lower elevations and over 120 inches (300 cm) per year in the higher elevations, the watershed's coniferous forests — trees such as western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Douglas fir (*Pseudotsuga menziesii*), true fir (*Abies* spp.), and western red cedar (*Thuja plicata*) — cover about 72 percent of the total land area. Hardwood species such as red alder (*Alnus rubra*) and maple (*Acer* spp.) also grow throughout the region, especially as second growth in riparian areas, covering about 11 percent of the watershed. Most of the older trees have been lost to fire and timber harvest. Today, hemlock and spruce are the dominant tree species in the watershed. Foresters describe this environment as a highly productive ecosystem — from both biological and commodity perspectives (c.f., TBNEP 1998).

In the lower elevations of the watershed, forest gives way to wetlands and rich alluvial plains used for agriculture, rural residential housing, and urban development.

The Necanicum River watershed drains into the Pacific Ocean at Seaside (Figures 1.1, 1.2). The Necanicum River drains approximately 83.7 sq. mi. of land, characterized by steep forested uplands and flat alluvial lowlands. Much of the higher elevations have been used for timber production, and are now on their second or third rotation, or were burned. The lower watershed contains extensive wetland areas and is dominated by urban and rural residential development.

Necanicum Watershed

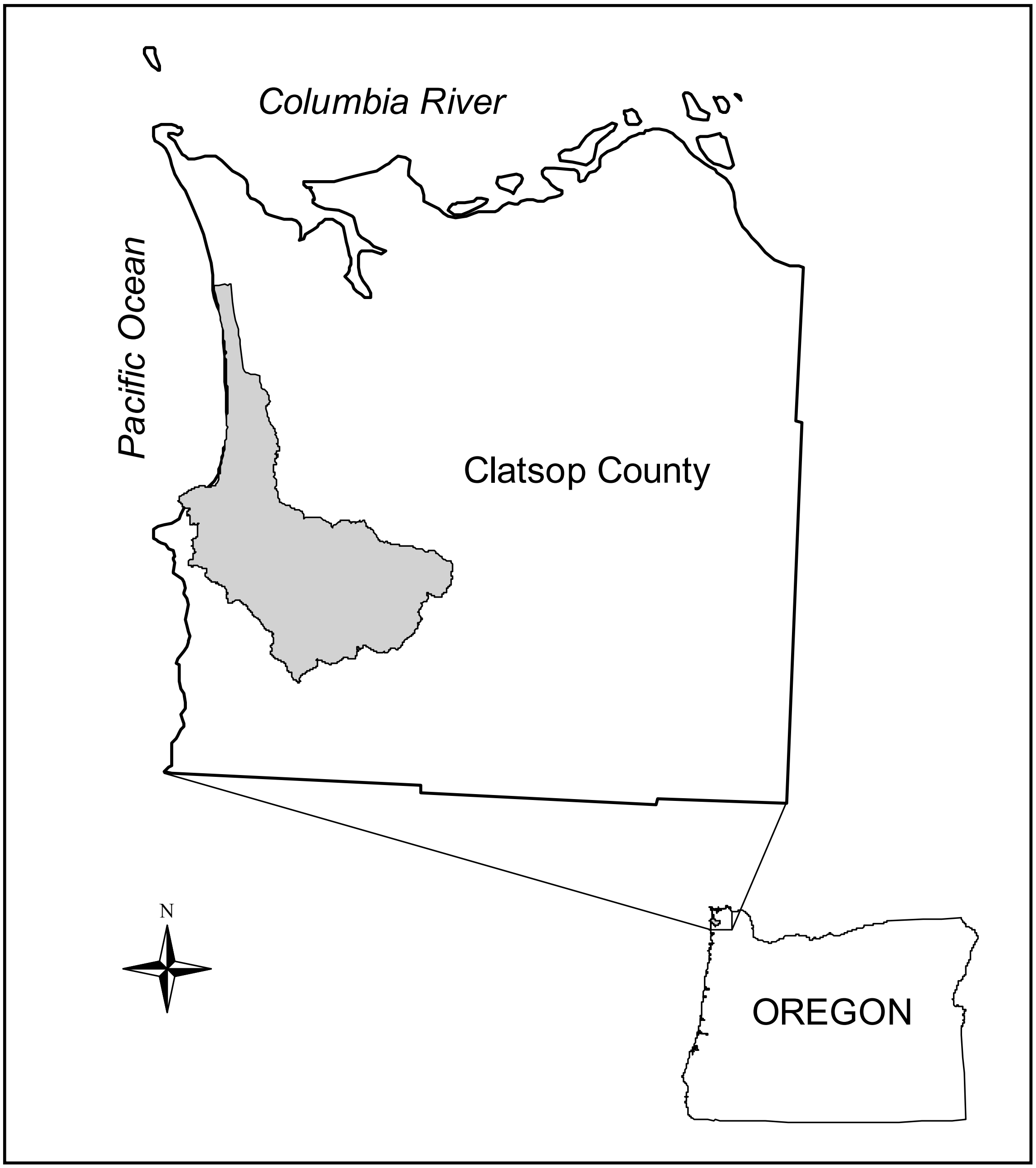


Figure 1.1. Physical location of the Necanicum River watershed.

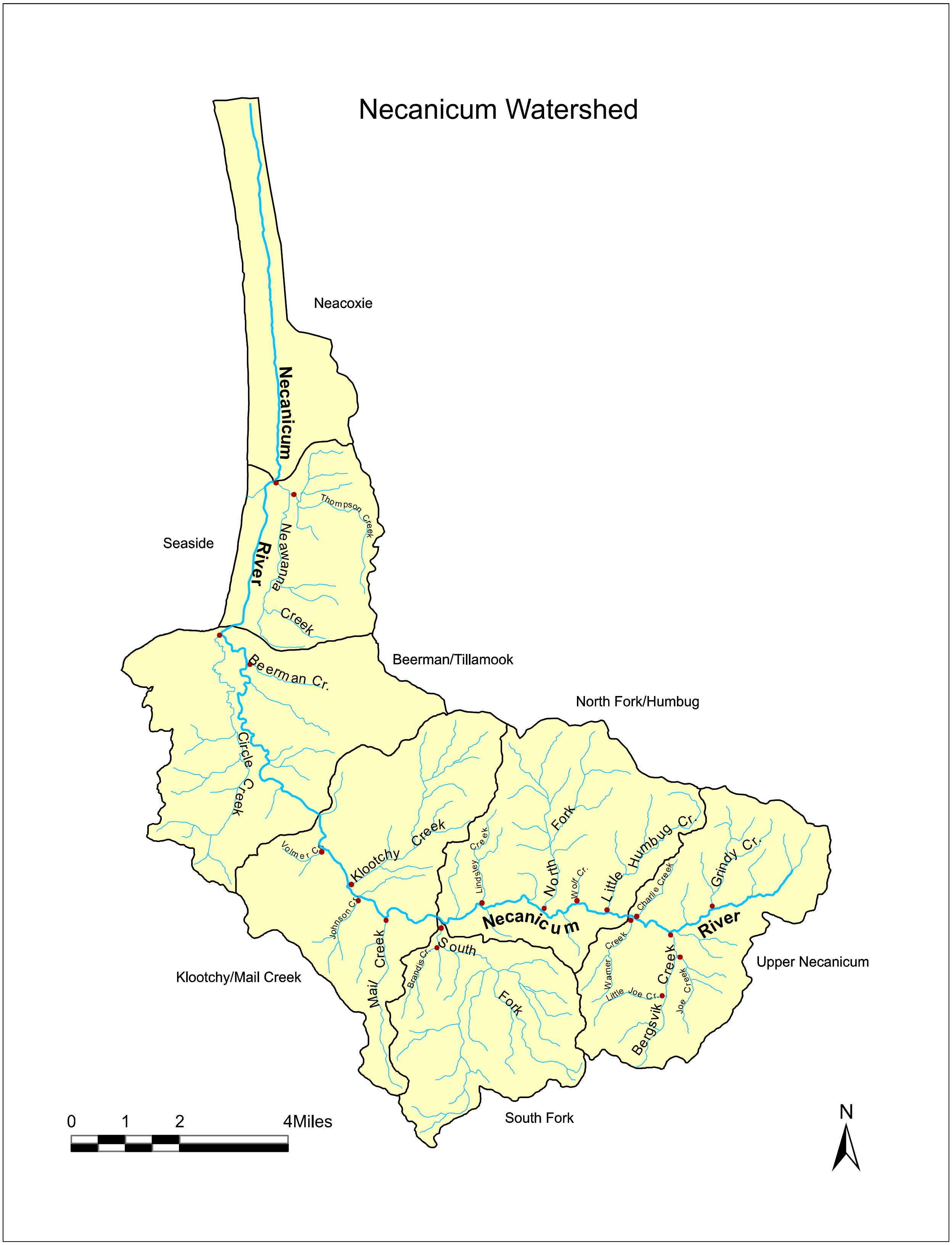


Figure 1.2. Map of Necanicum River watershed showing subwatershed boundaries and stream network, with names of streams indicated.

There is a general lack of information on the current condition of estuarine ecosystems in Oregon (Good 2000), including the Necanicum. This lack of information is especially acute with respect to comparing current with historical conditions. Effects of land use on estuarine health have not been well quantified. Both past and current water quality are poorly understood because of limited monitoring of the estuarine environment. It is believed, however, that loss of estuarine wetlands has been a significant problem in the Necanicum River watershed (Neal Maine, pers. comm., December, 2001).

The watershed is divided into seven subwatersheds (Figure 1.3), two of which (Seaside and Neacoxie) are heavily populated. The Neacoxie subwatershed includes extensive areas of rural residential and urban development. The western half of the Seaside subwatershed is largely urban.

Increasing population, development, and tourism pose potential threats to the Necanicum River Estuary and its associated watershed. Point and nonpoint source pollution from the watershed, shoreline land use, and oil spills continue to threaten the quality of all of Oregon's estuarine waters. Introductions of exotic species, especially *Spartina*, and the risk of increasing water withdrawals also pose risks.

Eelgrass beds are threatened by sedimentation, excessive nutrient levels, and introduced nuisance species. For example, nutrients can stimulate algal blooms, which can smother eelgrass; *Spartina* can displace eelgrass in part of its tidal range (NOAA 1998, U.S. EPA 1998, Good 1999).

1.3 Ecoregions

The state of Oregon has been divided into ecoregions based on climate, geology, physiography, vegetation, land use, wildlife and hydrology. Each of these ecoregions has characteristic patterns of climate, geology, topography, and natural vegetation that shape and form the function of the watersheds. Dividing the state and the watersheds into different ecoregions permits regional characteristics to be identified. The Necanicum River watershed spans portions of four ecoregions (Omernik and Gallant 1986): the Coastal Lowlands, Coastal Uplands, Volcanics, and a small part of the Willapa Hills ecoregions.

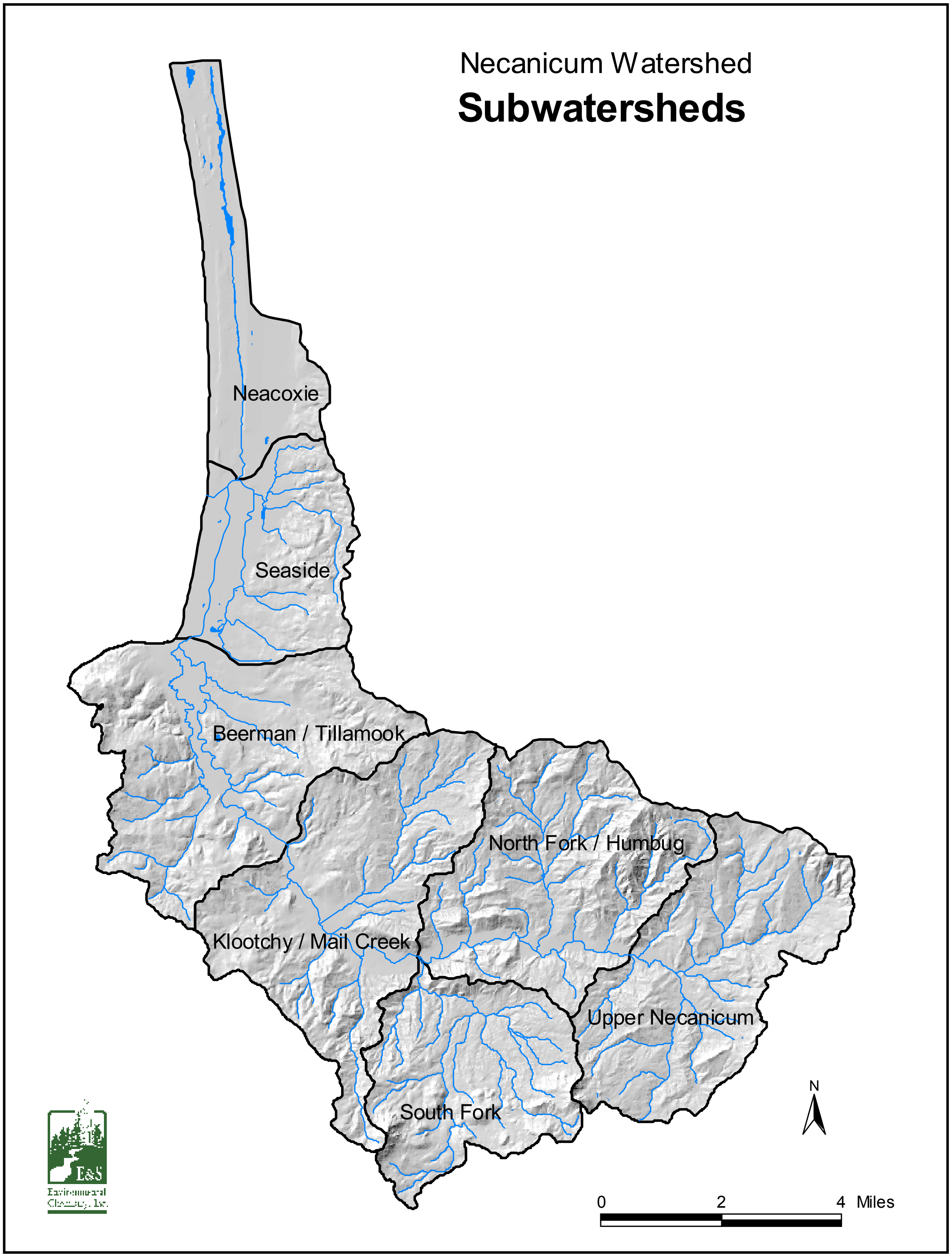


Figure 1.3. Subwatersheds in the Necanicum River watershed illustrating topography based on a 10 m Digital Elevation Model (DEM).

The Coastal Lowland ecoregion occurs in the valley bottoms of the Oregon and Washington coast and is characterized by estuaries and terraces with low gradient meandering streams. Channelization and diking of these streams is common. Elevations in this ecoregion run from 0 to 300 ft and the land receives 60 to 85 in of annual rainfall. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir (*Abies grandis*), red alder, and estuarine wetland plants (Omernik and Gallant 1986, Franklin and Dyrness 1973).

The Coastal Upland ecoregion extends along the Oregon and Washington coast and is typically associated with the upland areas that drain into the Coastal Lowlands ecoregion. The Coastal Uplands ecoregion is characterized by coastal upland and headland terraces with medium to high gradient streams. Elevations run from 0 to 500 ft and the land receives 70 to 125 in of precipitation. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Omernik and Gallant 1986, Franklin and Dyrness 1973).

The Volcanics ecoregion extends from the upper extent of the Coastal Uplands ecoregion to beyond the summit of the Coast Range mountains. The Volcanics ecoregion is characterized by steeply sloped mountains with high-gradient, cascading streams and rivers. Elevations range from 1,000 to 4,000 feet and the region receives 70 to 200 inches of precipitation annually. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Omernik and Gallant 1986, Franklin and Dyrness 1973).

The Willapa Hills ecoregion extends from the southern portion of Clatsop County north to the southern extent of Puget Sound. This ecoregion is characterized by low rolling hills and mountains with medium gradient streams. Elevations range from 0 to 3,000 feet and the land receives 50 to 100 inches of precipitation annually. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Franklin and Dyrness 1973).

1.4 Population

From 1990 to 2000, the population of Oregon increased by 20.4 percent and the population of Clatsop County increased by approximately 7 percent (U.S. Bureau of Census; *http://quickfacts.census.gov/*). Population growth in Oregon, and especially in Clatsop County, historically depended on fluctuations in the natural resource industries. In recent years,

population growth has been less a reaction to natural resource industries and more a function of living conditions and quality of life concerns. The current population of Clatsop County is 35,630, based on U.S. Bureau of Census data for 2000.

Within the watershed, the human population is concentrated in and around the city of Seaside and to a lesser extent in the southern portion of the Neacoxie subwatershed (Figure 1.4). In the upper portions of the watershed, the sparse population is concentrated along the mainstem Necanicum River. Most of the upland areas have a population density less than 10 people per square mile (Figure 1.4).

1.5 Climate and Topography

Topography in the Necanicum River watershed is typical of the Pacific Northwest coast, where the terrain is characterized by steep upland slopes which provide sediment and organic material to the agricultural and developed land below. Much of the lowlands included historic floodplains, some of which were drained and diked for development purposes. Elevations in the watershed range from sea level at the mouth to 2,846 feet in the headwaters.

The Necanicum River watershed experiences a coastal temperate climate strongly influenced by the Pacific Ocean and related weather patterns (Taylor and Hatton 1999). Climate usually includes an extended winter rainy season followed by a dry summer season. Precipitation patterns reflect a strong orographic effect in which precipitation increases with elevation as moist air masses rise over high terrain causing them to cool and drop more precipitation. Mean annual precipitation ranges from about 80 inches in the lowlands to over 120 inches in the highlands, based on the PRISM model which accounts for these orographic effects (Daly et al. 1994). Rainfall is the primary source of precipitation in the Necanicum River watershed. The highest precipitation events generally occur during November, December, and January.

The seasonal, episodic nature of precipitation defines the natural system. Coho migrate upstream with the first heavy rains in late autumn. Big winter storms can cause landslides in the steeply sloped upland regions. Although heavy storms have characterized the natural system for thousands of years, human activities have exacerbated the impacts and consequences of high rainfall (Coulton et al. 1996). Westerly winds predominate and carry the temperature-moderating effects of the ocean over all of western Oregon. Summers are warm and dry; winters wet and

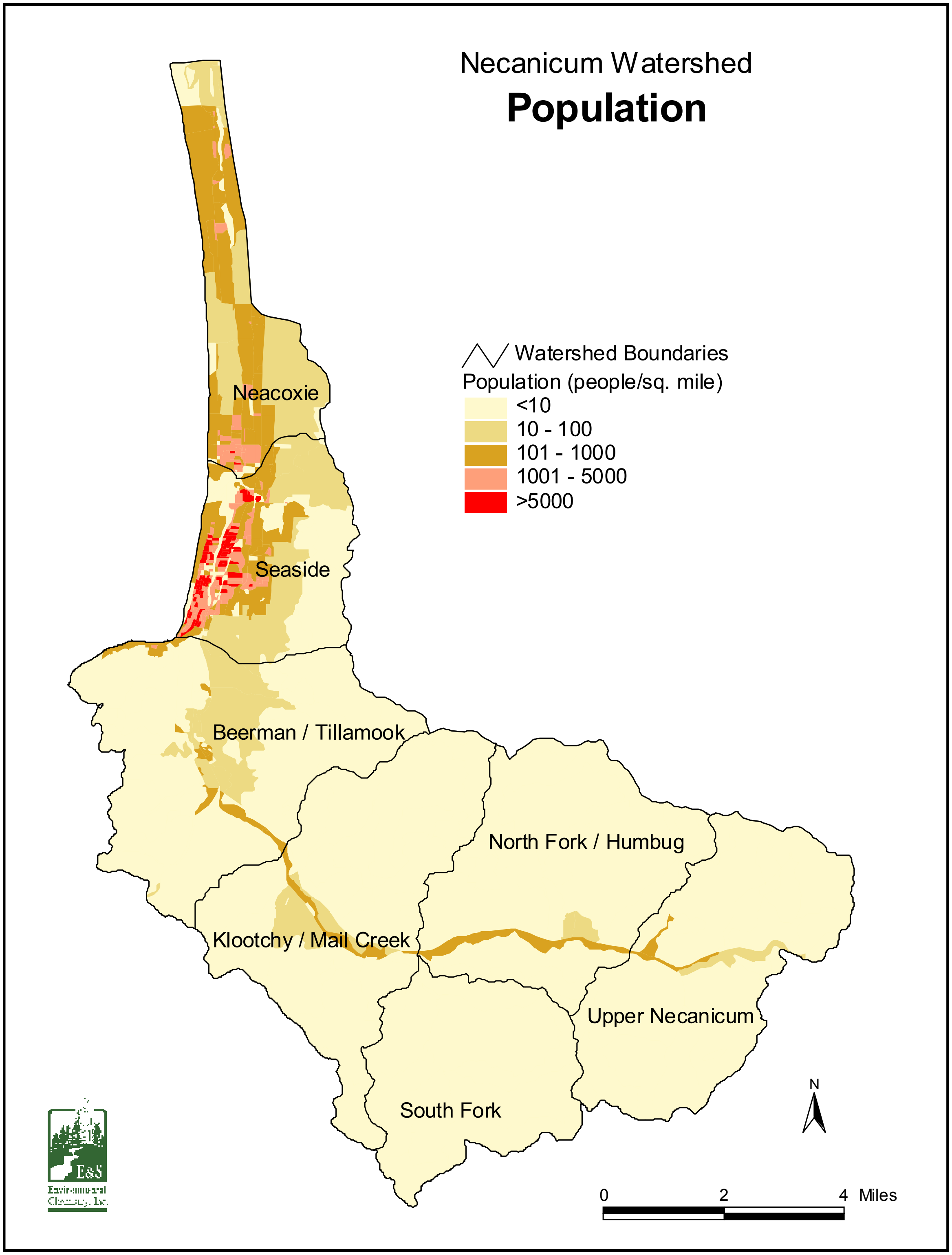


Figure 1.4. Population distribution within the Necanicum River watershed.

moderate (USDA 1964). Prevailing winds are from the northwest during summer and southwest during winter. Winds frequently reach gale force during winter storms.

1.6 Geology

The Necanicum River and its watershed are situated in typical Pacific Northwest coastal terrain. A relatively straight coastline consists of miles of sandy beaches punctuated with cliffs of igneous rock and small inlets. East of the Pacific Coast, the high, steep ridges of the Coast Range climb up to 3,500 feet (1,064 m). These upland areas consist mostly of volcanic basalt base material with overlying soils formed from basalt, shale, and sandstone material. Topography is dominated by steep mountains, dissected terraces, and river valleys. Much of Clatsop County consists of old marine sediments that have been uplifted by intrusive basalt and covered in places by basalt flows. Most of the higher mountain areas are basaltic in nature, and include breccia basalt, tuff breccia, and basaltic flow rock.

The Necanicum River is the main drainage in the southwestern part of Clatsop County. Its headwaters are in the Humbug Mountain area. The South Fork Necanicum River has its headwaters in the Sugarloaf and Kidders Butte area.

Floodplains are dominated by Grindbrook-Walluski-Hebo soils along the mainstem Necanicum River. These are deep silt loam and silty clay loam soils, often occurring on terraces. To the north, along Neacoxie Creek, floodplain soils are Waldport-Gearhart-Brallier soils that are very deep, fine sand, fine sandy loam, and mucky peat. These soils are found on dunes and in swales.

Upland soils are mainly Skipanon-Templeton-Svensen soils that are deep, well-drained gravelly silt loams, silt loams, and loams. There are also considerable areas of Klootchy-Necanicum-Ascar soils that are deep, well drained silt loams, gravelly loams, and extremely gravelly loams (Clatsop County Soil Survey).

1.7 Vegetation

1.7.1 Potential Natural Vegetation

Human activities have greatly altered the vegetation of the watershed. Since the 19th century, European-Americans have cleared and harvested trees, drained wetlands, established pastures, and developed urban and rural residential areas. Today, most of the mixed conifer upland forests in the Necanicum River watershed have been harvested and replanted in hemlock

and spruce trees. The natural, or potential vegetation of the watershed is distributed between the Sitka spruce and western hemlock vegetation zones. These two vegetation zones extend from British Columbia to Northern California, running roughly parallel to the coast, with the hemlock zone also enclosing the Willamette Valley (Franklin and Dyrness 1973).

The spruce zone covers the lower regions of the watershed and normally occurs at elevations below 450 feet (150 meters). It is a wet zone with annual precipitation ranging between 118 inches (300 cm) and 78 inches (200 cm). The nearby ocean adds frequent summer fogs and moisture to otherwise dry months and distinguishes the spruce zone from the higher elevation hemlock zone. The temperature averages 51ºF (10.6ºC) annually with an average January minimum of 40ºF (4.7ºC) and a July maximum of 70ºF (20.6ºC) at Astoria.

Dense, tall stands of Sitka spruce, western hemlock, western red cedar, Douglas fir, and grand fir dominate the spruce zone. In dune areas close to the ocean, shore pine (*Pinus contorta contorta*) is locally common. Hardwood species occurring in the zone include red alder, bigleaf maple (*Acer macrophyllum*), and occasional California bay (*Umbellularia californica*) with red alder dominating recently disturbed sites and some riparian areas. Understory vegetation is generally composed of a dense growth of shrubs, herbs, ferns, and mosses. Common native species include sword fern (*Polystichum munitum*), wood sorrel (*Oxalis oregona*), red and evergreen huckleberry (*Vaccinium parvifolium* and *V. ovatum*), and red elderberry (*Sambucus racemosa*).

Successional patterns in the spruce zone following fire or logging are often dominated by a dense shrub community composed of salmonberry (*Rubus spectabilis*), sword fern, elderberry, and huckleberry, with the relative dominance varying with the site conditions. The shrub community can persist for quite some time due to the excellent growing conditions, but at some point it yields to one of two types of seral forest stand. The conifer type is a mixture of spruce, hemlock, and Douglas fir and the hardwood type is a monotypic, dense stand of red alder. Replacement of the alder stand by conifers can be very slow, due to the shade provided by the dense shrub understory.

The hemlock zone normally extends in elevation between 450 feet (150 meters) and the subalpine zone of the Coast Range. With less ocean influence and summer fog, the upland hemlock zone still receives heavy precipitation. In fact, the upland regions average up to 142 inches (360 cm) of rain each year, concentrated during fall to late spring. The zone temperature averages 50ºF (9.6ºC) annually with a January minimum of 30ºF (-0.7ºC) and a July maximum

of 78° F (25.6 °C). The soils are derived from sedimentary and basalt parent materials, of moderate depth and medium acidity, with a high infiltration rate.

In the hemlock zone, the dominant vegetation is dense conifer forest. Forest stands are dominated by Douglas fir, western hemlock, and western red cedar, with other conifers mixed in, such as grand fir, and Sitka spruce. Hardwood species occurring in the hemlock zone include red alder, bigleaf maple, black cottonwood (*Populus trichocarpa*), and Oregon ash (*Fraxinus latifolia*). Understory vegetation varies with moisture regimes, and includes sword fern, wood sorrel, vine maple (*Acer circinatum*), and Oregon grape (*Mahonia nervosa*).

Successional patterns in the hemlock zone following fire or clearcut logging bring the first year residual species and invading herbaceous species from the genera *Senecio* and *Epilobium*. This community is replaced during years two to five by one dominated by fireweed (*Epilobium angustifolium*), thistle (*Cirsium vulgare*), and bracken fern (*Pteridium aquilinum*). The next community is dominated by shrubs such as vine maple, Oregon grape, salal, and blackberry species (*Rubus* spp.). Eventually, the shrubs are overtopped by conifers such as Douglas fir (TBNEP 1998).

1.7.2 Historic Floodplain Vegetation

Historically, the Necanicum River floodplains were likely dominated by river bottom forest which consisted of a variety of trees, including black cottonwood, Sitka spruce, red alder, western hemlock, grand fir, big-leaf maple, and western red cedar. Spruce trees up to 80 inches in diameter and hemlock 60 inches in diameter were used as bearing trees by the early surveyors. These forested floodplains provided woody debris to the lower river and estuary ecosystems, which added complexity and nutrients to the rivers and helped to nurture and sustain fish populations. The forests slowed and regulated flooding across the valley floodplains, reduced erosion, and encouraged sediment deposition (Coulton et al. 1996). These forested bottomlands have been replaced by open areas and developed lands with little or no woody vegetation in the riparian zone.

1.7.3 Current Vegetation

Vegetation cover in the Necanicum River watershed was characterized using the 1995 CLAMS data (Figure 1.5). CLAMS characterized the vegetation by classifying satellite imagery

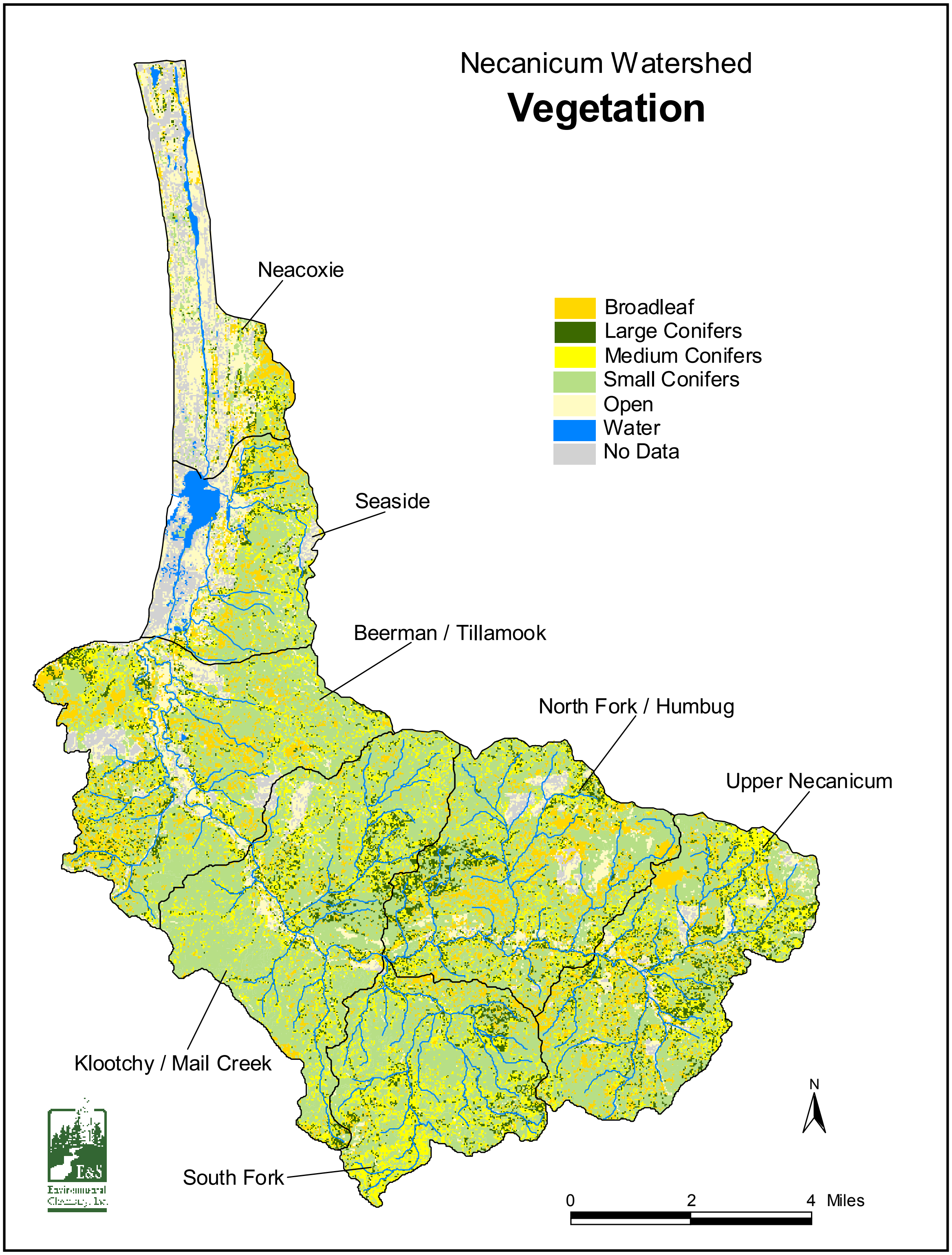


Figure 1.5 Vegetation cover in the Necanicum River watershed. Vegetation was characterized using CLAMS data. Vegetation categories have been aggregated to show the relative distribution of conifers.

into 11 categories (Table 1.2). The satellite data were acquired in 1988 and updated in 1995. It is important to note that only pixels that had greater than 70 percent cover were characterized as forest types. For example, a pixel that has less that 70 percent cover is characterized as either open or semi-open. If the pixel demonstrates a greater than 70 percent cover, it is further characterized into one of categories 6 through 14. Garono and Brophy (1999) summarized CLAMS data for the Rock Creek watershed by combining these categories to describe the spatial patterns of conifers and open areas. We have used this same approach for the Necanicum River watershed.

Table 1.2. Eleven categories of land cover present in the 1995 CLAMS data set. Categories 0 = background, 1=shadow, 2=water, and 5= cloud are not shown (Garono and Brophy 1999). DBH is diameter at breast height.

Class	Cover type	Description
3	Open	Open (0-40% vegetation cover)
4	Semi-closed	Semi-Closed (41-70% vegetation cover)
6	Broadleaf	Broadleaf (#70% broadleaf cover)
7	Mixed, small conifers	Mixed broadleaf/conifer: <70% broadleaf cover; small conifers (# 1 ft [25 cm] DBH)
8	Mixed, medium conifers	Mixed: <70% broadleaf cover; medium conifers (1-2 ft [26-50 cm] DBH)
9	Mixed, large conifers	Mixed: <70% broadleaf cover; large conifers (2-3 ft [51-75 cm] DBH)
10	Mixed, very large conifers	Mixed: <70% broadleaf cover; very large conifers (> 3 ft [75 cm] DBH)
11	Conifer, small	Conifer: >70% conifer cover, conifers small (#1 ft [25 cm] DBH)
12	Conifer, medium	Conifer: >70% conifer cover, conifers medium (1-2 ft [26-50 cm] DBH)
13	Conifer, large	Conifer: >70% conifer cover; conifers large (2-3 ft [51-75 cm] DBH)
14	Conifer, very large	Conifer: >70% conifer cover; conifers very large (>3 ft [75 cm] DBH)

1.7.4 Large Conifers

Prior to European settlement, Oregon Coast Range forests were dominated by conifers (Franklin and Dyrness 1973). These forests were changed dramatically by human activities such

as forest harvest and natural catastrophic events such as forest fires, which changed both the age structure and species composition of these forests (Garono and Brophy 1999; TBNEP 1998). Conifers, especially old growth, played an important role in ecosystem function in coastal watersheds by providing shade and large woody debris to streams, slope stabilization, and habitat for wildlife (Naiman and Bilby 1998). Additionally, near-coast stands receive precipitation in the form of fog drip. Old growth forests generate more fog drip precipitation than younger stands. Understanding the age and distribution of conifers within a watershed is essential for managing the system to maintain ecosystem function.

Following the methodology provided in Garono and Brophy (1999), we divided large conifer data into two distinct classes: Mixed Forest/Large Conifers (Classes 9+10+13+14) and Large Conifers (Classes 13+14). The Mixed Forest/Large Conifers class contains those areas that include large conifers, but may be dominated by a broadleaf forest, whereas the Large Conifer Class is actually dominated by large conifers (>70 percent conifer cover). Large conifers are present in 7.4 percent of the watershed, with the majority occurring in mixed stands (7.0 percent; Table 1.3). The subwatershed having the highest percentage of large conifers (11.0 percent) is the uppermost subwatershed in the basin (Upper Necanicum). The two lowest subwatersheds (Neacoxie and Seaside) had the lowest percentage of large conifers (# 4.3 percent).

Most of the vegetation in the Necanicum River watershed is represented by mixed, small conifers (32.7 percent), small conifers (16.4 percent), and broadleaf vegetation (11.1 percent; Table 1.3). This is the result of clearcutting activities and fires. Although many of these areas have been replanted, they have not reached a state of maturity that would allow them to provide many of the watershed processes associated with old growth forests. Replanted stands rarely mimic natural vegetation communities and generally exhibit lower diversity in the overstory community than would be expected from a late-successional forest.

1.7.5 Open Areas

Open areas within a watershed can indicate pastureland and meadows as well as recently harvested timberlands. Open areas in the uplands can have a large influence on hydrology and slope failure (WPN 1999, Naiman and Bilby 1998, Binkley and Brown 1993). The CLAMS data were collected in 1995 and many of the open areas have most likely been replanted since that time. Consequently, these data represent the conditions as they existed in 1995, but not

Table 1.3. Vegetation cover in the Necanicum River watershed, based on satellite imaging classification from the 1995 CLAMS study (*http://www.fsl.orst.edu/clams*).

Vegetation Class	Beerman/Tillamook	Klootchy / Mail Creek	Neacoxie	North Fork / Humbug	Seaside	South Fork	Upper Necanicum	Grand Total
Broadleaf (>=70% broadleaf cover)	15.67	4.94	8.54	15.76	10.11	5.46	14.42	11.14
Small conifers (<=25cm DBH)	13.40	24.04	5.30	18.94	9.73	14.26	20.56	16.43
Medium conifers (26-50cm DBH)	3.20	7.96	0.72	3.74	4.05	15.79	4.94	5.79
Large conifers (51-75cm DBH)	0.24	0.24	0.11	0.41	0.33	0.67	0.58	0.37
Mixed - Small conifers (<25cm DBH)	36.13	41.09	6.28	33.99	25.92	43.64	28.48	32.72
Mixed - Medium conifers (26-50cm DB	10.20	9.59	2.67	9.55	6.20	11.38	12.84	9.48
Mixed - Large conifers (51-75cm DBH	5.85	6.40	3.30	8.24	3.84	7.27	10.23	6.79
Mixed - Very large conifers (>75cm	0.14	0.19	0.20	0.32	0.13	0.39	0.22	0.23
Open (0-40% vegetation cover)	9.72	4.12	42.05	6.18	16.03	1.12	5.55	9.89
Water	0.01	0.00	0.88	0.00	7.13	0.00	0.01	0.79
No Data*	5.43	1.43	30.00	2.85	16.53	0.07	2.17	6.38

* Includes locations obscured by clouds and shadows on the satellite imagery.

necessarily as they exist today. Pacific Northwest forest ecosystems are constantly in a state of flux, whereby open areas are replanted, and new open areas created through clearcutting or fire. Open areas represent a rather small proportion of the Necanicum River watershed, accounting for approximately 9.9 percent of the total area (Table 1.3). Most of the open areas are associated with developed areas, wetlands, and agricultural areas in the lowlands. Upland open areas are likely primarily associated with wetlands, which are considered natural open areas in the watershed, and with clearcuts.

1.8 Land Use

Watershed processes are often affected by land management practices which increase watershed disturbance. For example, management of forest land for timber harvest can influence watershed hydrology (increased peak flows) by increasing road densities, clearing vegetation, and reducing evapotranspiration (WPN 1999; Naiman and Bilby 1998). Wetlands have sometimes been drained for agriculture because of their rich organic soils, resulting in habitat

loss and the disconnection of floodplains from the rivers. By understanding the land management activities, land managers and watershed council members can better evaluate the effects of watershed disturbance on their watersheds and plan how to mitigate those impacts on natural ecosystem processes.

The dominant land use in the Necanicum River watershed is private industrial forest, accounting for 74 percent of the watershed's total area (Table 1.4; Figure 1.6). The lowland areas of the watershed are dominated by developed areas in and around Seaside. Over seven percent of the watershed is palustrine and estuarine wetland. Watershed processes in the Necanicum River watershed today are most likely affected by changes in forest management, increased development to accommodate population growth, and floodplain and wetland loss. Specific habitat and water quality related effects typically associated with land use activities are listed in Table 1.5.

1.9 Channel Habitat Types

Stream channels were separated into channel habitat type categories using the OWEB protocol. Categories were based on stream geomorphic structure, including stream size, gradient, and side-slope constraint (Table 1.6). By identifying current channel forms in the watershed, we can better predict how land use activities may have affected the channel form as well as identify how different channels may respond to particular restoration efforts. Ultimately, changes in watershed processes will affect channel form and produce changes in fish habitat.

Channel responses to changes in ecosystem processes are strongly influenced by channel confinement and gradient (Naiman and Bilby 1998). For example, unconfined channels possess floodplains that mitigate peak flow effects and allow channel migration. In contrast, confined channels translate high flows into higher velocities with greater basal shear stress. Ultimately, these characteristics control stream conditions such as bedload material, sediment transport, and fish habitat quality. Generally, more confined, higher gradient streams demonstrate little response to watershed disturbances and restoration efforts (Figure 1.7). By grouping the channels into geomorphologic types, we can determine which channels are most responsive to disturbances in the watershed as well as those channels most likely to respond to restoration activities.

Table 1.4. Land use in the Necanicum River watershed calculated from the refined land use coverage.

Subwatershed	Wetland/ Agriculture %	Agriculture %	Estuarine %	Mine %	Palustriine %	Private Industrial Forest %	Private Non-Industrial Forest %	Rural Residential %	State Forest %	State Park %	Urban %	Water %
Beerman/Tillamook	1.83	1.70	0.25	0.08	4.43	73.04	10.56	2.05	2.66	2.93	0.43	0.04
Klootchy/Mail Creek	-	-	-	-	1.69	95.08	2.26	0.97	-	-	-	-
Neacoxie	-	-	0.20	-	37.24	9.11	8.45	18.17	-	10.60	14.27	1.95
North Fork/Humbug	-	-	-	-	3.51	91.03	4.18	1.06	0.23	-	-	-
Seaside	-	-	3.22	-	14.46	43.94	15.01	0.13	-	-	22.26	0.98
South Fork	-	-	-	-	-	84.95	15.05	-	-	-	-	-
Upper Necanicum	-	-	-	-	3.01	80.89	7.50	0.74	7.86	-	-	-
Total	0.34	0.32	0.39	0.01	6.91	74.16	8.30	2.47	1.79	1.48	3.55	0.28

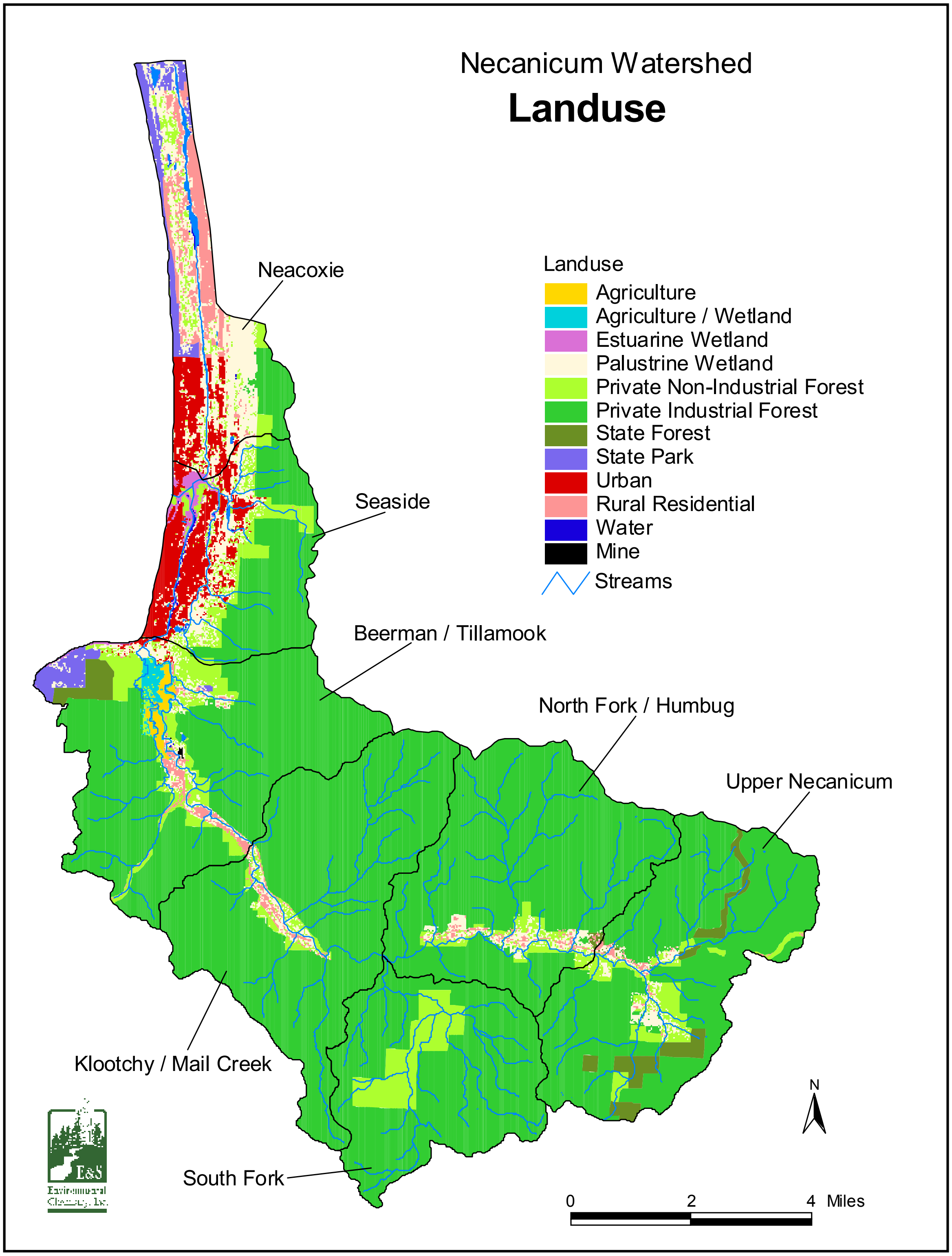


Figure 1.6. Land use in the Necanicum River watershed. Data displayed are from the refined land use coverage. Also shown are the names and boundaries of the subwatersheds.

Table 1.5. Typical watershed issues organized by major land use activity (WPN 1999)

Land Use Category	Habitat-Related Effects	Water Quality Effects
Forestry	Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Flow alteration Passage barriers	Temperature Turbidity Fine sediments Pesticides and herbicides
Crop-land grazing	Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Flow alteration	Temperature Dissolved oxygen Turbidity Fine sediments Suspended sediments Nutrients, bacteria Pesticides and herbicides
Feedlots and dairies	Channel modification	Suspended sediments Nutrients Bacteria Pesticides and herbicides
Urban areas	Flow alteration Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Passage barriers	Temperature Dissolved oxygen Turbidity Suspended sediments Fine sediments Nutrients Organic and inorganic toxics Bacteria
Mining	Channel modification Pool quantity and quality Substrate quality	Turbidity Suspended sediments Fine sediments Nutrients Organic and inorganic toxics
Dams and irrigation works	Flow alteration Channel modification Pool quantity and quality Substrate quality Passage barriers	Temperature Dissolved oxygen Fine sediments
Road networks	Flow alteration Channel modification Pool quantity and quality Substrate quality Passage barriers	Turbidity Suspended sediments Fine sediments

Table 1.6. Channel habitat types and their associated channel geomorphologic conditions (WPN 1999)				
Code	CHT Name	Channel Gradient	Channel Confinement	Channel Size
ES	Small Estuary	<1%	Unconfined to moderately confined	Small to medium
EL	Large Estuary	<1%	Unconfined to moderately confined	Large
FP1	Low Gradient Large Floodplain	<1%	Unconfined	Large
FP2	Low Gradient Medium Floodplain	<2%	Unconfined	Medium to large
FP3	Low Gradient Small Floodplain	<2%	Unconfined	Small to medium
AF	Alluvial Fan	1-5%	Variable	Small to medium
LM	Low Gradient Moderately Confined	<2%	Moderately confined	Variable
LC	Low Gradient Confined	<2%	Confined	Variable
MM	Moderate Gradient Moderately Confined	2-4%	Moderately confined	Variable
MC	Moderate Gradient Confined	2-4%	Confined	Variable
MH	Moderate Gradient Headwater	1-6%	Confined	Small
MV	Moderately Steep Narrow Valley	3-10%	Confined	Small to medium
BC	Bedrock Canyon	1 - >20%	Confined	Variable
SV	Steep Narrow Valley	8-16%	Confined	Small
VH	Very Steep Headwater	>16%	Confined	Small

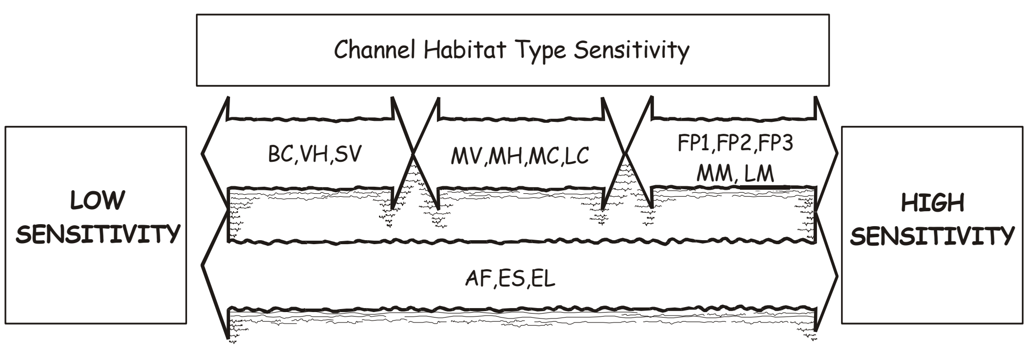


Figure 1.7. Different channel types respond differently to adjustment in channel pattern, location, width, depth, sediment storage, and bed roughness. Such changes may not only result in alteration of aquatic habitat, but the more responsive areas are most likely to exhibit physical changes from land management activities and restoration efforts. (WPN 1999)

Topography in the Necanicum River watershed is characterized by steep to moderately steep gradient uplands that move quickly into low gradient lowlands. Low gradient streams with extensive floodplains tend to be especially sensitive to the effects of watershed disturbance. Thirty percent of the channels in the Necanicum River watershed are characterized as low gradient, high sensitivity streams (Table 1.7; Figures 1.7, 1.8). One third of the streams in the watershed are confined, high gradient streams that demonstrate a low sensitivity to restoration and watershed disturbance.

Stream segments designated as low gradient small or medium flood plain, low gradient moderately confined, and medium gradient moderately confined represent potential sites for in-stream and riparian zone restoration (WPN 1999). The length of stream in each subbasin that falls into one of these CHT classes is presented in Table 1.7. These data should be interpreted as indicative of a high probability that restoration work would be successful if such restoration work was needed and implemented.

Table 1.7. Channel habitat types in the Necanicum River watershed. Channel habitat types are grouped by their sensitivity to watershed disturbance.

		PERCENT CHANNEL HABITAT TYPE							
Channel Sensitivity		Low		Moderate		High			
Subwatershed	Stream Length (mi)	% SV	% VH	% MC	% MV	% FP2	% FP3	% LM	% MM
Beerman/Tillamook	25.34	18.3	1.2	9.3	17.4	24.6	18.3	3.3	7.6
Klootchy/Mail Creek	26.61	30.3	11.2	3.4	18.4	14.5	-	9.8	12.3
Neacoxie	7.08	-	-	-	-	-	-	100.0	-
North Fork/Humbug	31.10	46.0	4.6	-	21.2	2.8	-	16.7	8.6
Seaside	18.99	14.6	0.9	-	8.1	25.4	16.8	14.5	19.7
South Fork	26.77	42.2	5.6	5.0	41.6	-	-	4.0	1.6
Upper Necanicum	27.48	26.6	1.4	-	27.8	-	-	22.3	22.0
Total	163.36	29.6	4.2	2.8	22.2	9.6	4.8	15.7	11.1

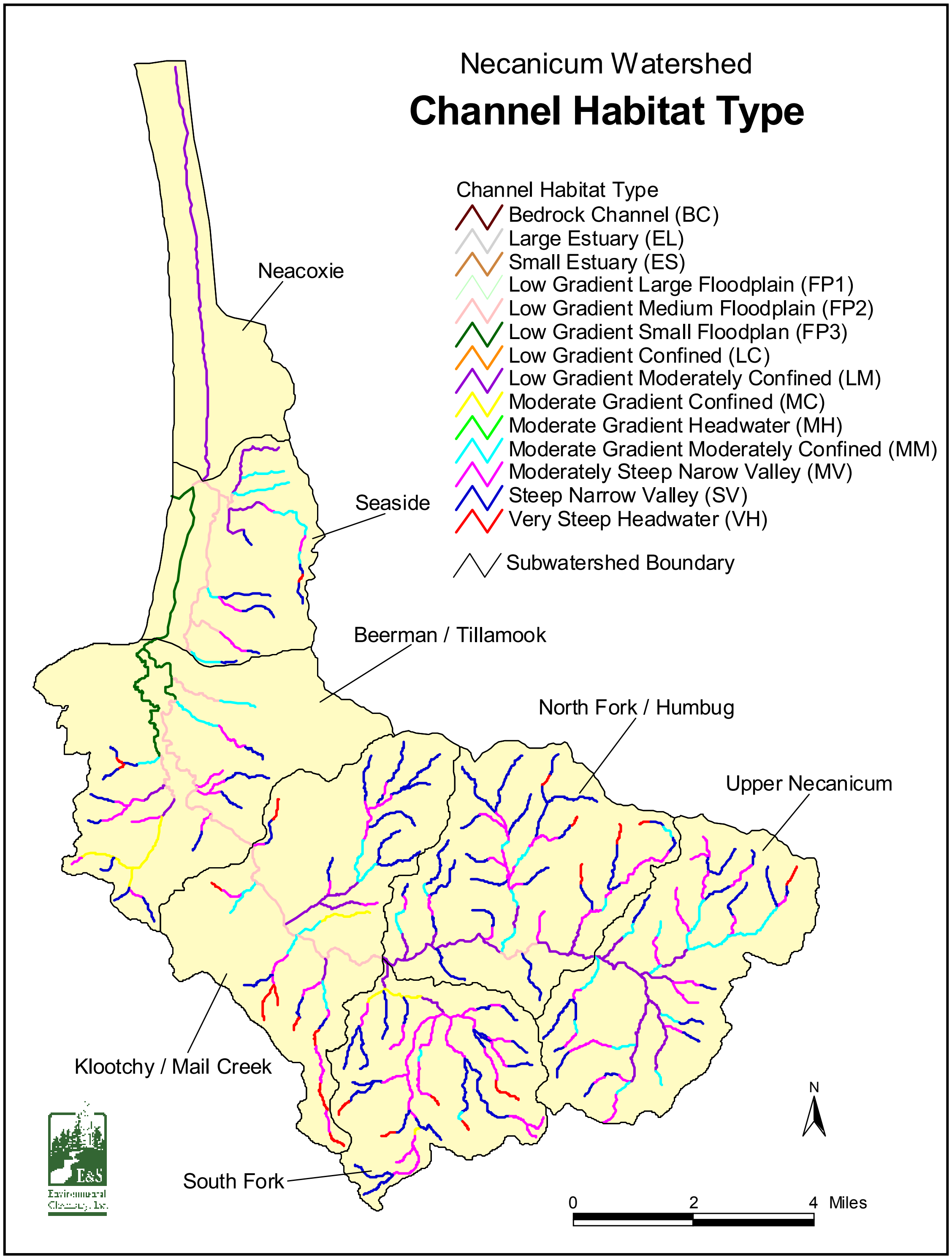


Figure 1.8. Channel habitat types in the Necanicum River watershed. Stream reaches were classified by slope, size, and side-slope according to OWEB protocols (WPN 1999).

CHAPTER 2. FISHERIES

2.1 Introduction

The OWEB assessment method focuses on watershed processes that affect salmonids and their associated habitats. Understanding the current condition of salmonid populations in a watershed is vital to identifying the effects of the spatial and temporal distribution of key habitat areas. Additionally, salmonids are often used as indicator species under the assumption that they are among the most sensitive species in a stream network (WPN 1999, Bottom et al. 1998, Tuchmann et al. 1996). Habitat conditions that are good for salmonids generally reflect good habitat conditions for other species of aquatic biota. Understanding the complex life cycles, spatial distribution, and current status of salmonids in a watershed is key to evaluating watershed management practices and their effects on watershed health. Ocean conditions also affect salmonids and populations may be low when ocean conditions are poor.

In 1994, in response to growing concerns about salmon health on the west coast, the National Marine Fisheries Service (NMFS) began the most thorough scientific review of Pacific salmon ever conducted. The review identified 52 distinct salmon and steelhead populations, known as Evolutionarily Significant Units (ESUs), of Pacific salmon in Oregon, Washington, Idaho, and California. Of these populations, 26 have been listed as threatened or endangered under the Endangered Species Act (ESA) and most others are in decline or at very low levels (NMFS 2000). These listed fish populations are considered likely to become endangered within the foreseeable future and their current threatened status cannot be explained solely by ocean cycles or other natural events. They are at risk of extinction primarily due to human activities, including over-fishing, habitat destruction, hydropower development, hatchery practices, and degraded water quality.

In June, 2000, the NMFS adopted the 4(d) Rule prohibiting the "take" of 14 groups of salmon and steelhead listed as threatened under the ESA. This rule prohibits anyone from taking a listed salmon or steelhead or from engaging in activities that are likely to harm the fish. The rules apply to everyone, including state, city, and county government, every business, and each citizen.

NMFS (2000) provided a list of activities that could be considered harmful to listed fish. The list includes the following activities (and also others not provided here):

- constructing or maintaining structures (e.g., culverts, berms, dams) that eliminate or impede a listed species' ability to migrate or gain access to habitat;

- discharging pollutants into a listed species' habitat;
- removing biota required for feeding, sheltering, or other essential behavior;
- removing or altering rocks, soil, gravel, vegetation, or other physical structures that are essential to habitat integrity;
- removing water or altering streamflow in a manner that significantly impairs spawning, migration, feeding, or other essential behavior;
- various streambed disturbances;
- various shoreline and riparian disturbances.

2.2 Fish Presence

Anadromous salmonid species known to occur in the Necanicum River watershed include chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and sea-run cutthroat trout (*O. clarkii*; Table 2.1). The chinook salmon were introduced; others are native. An anadromous species of lamprey (Pacific lamprey [*Entosphenous tridentatus*]) is also found in the Necanicum River. Although details of their life history and habitat requirements differ substantially (Table 2.2), all spawn in fresh water, migrate through the estuary, and rear for varying lengths of time in the ocean before returning to their natal streams to complete their life cycle. Resident cutthroat trout, brook lamprey (*Lamptera planeri*), and sculpins (*Cottus* spp.) are also present throughout the watershed. Starry flounder (*Platichthys stellatus*), staghorn sculpin (*Leptocottus armatus*), several species of surf

Table 2.1. Status of anadromous fish occurring in the Oregon Coastal ESU. Listing status was obtained from the NMFS website (*http://www.nwr.noaa.gov*).

Fish	ESU[1]	Status
Coho	Oregon Coast	Threatened
Coastal Cutthroat	Oregon Coast	Candidate
Chum	Oregon Coast	Not Listed
Chinook	Oregon Coast	Not Listed
Steelhead	Oregon Coast	Candidate

[1] An Evolutionarily Significant Unit or "ESU" is a genetically or ecologically distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

Table 2.2. Life history patterns for species of concern in the Necanicum River watershed.

Fish	Return	Spawn	Out-migration
Coho [1]	Oct. thru Jan.	Oct. thru Jan.	Spring
Chinook, fall [1]	Sept. thru Nov.	Oct. thru Dec.	Summer
Steelhead, winter [1]	Nov. thru May	Jan. thru May	Mar-June
Coastal Cutthroat[1]	Aug. thru Oct., peak	Dec thru April	Apr-Jun
Chum[2]	Oct-Nov	Nov-Dec	Spring

[1] Return and spawn dates were provided by W. Weber, based on personal and professional observations specific to the Necanicum River watershed, conversations with anglers, and ODFW spawning survey information.
[2] Status Report: Columbia River Fish Runs, 1938-1997

perch, and other miscellaneous estuarine species are found in the tidal portions of the watershed's streams as well as within the estuary.

Peak fish counts recorded for tributaries of the Necanicum River in 1996, 1997, and 1998 are listed in Table 2.3. Coho, chinook, and steelhead were all more abundant in these tributaries in 1996 than in 1997 and 1998. Larger numbers of fish were recorded for the South Fork of the Necanicum River than for the other surveyed tributaries in 1996. These data must be interrpeted with caution because mainstem surveys were not conducted and because the steelhead counts may represent almost exclusively early-spawning hatchery steelhead (W. Weber, retired, ODFW, pers. comm., March, 2002).

2.3 Species of Concern

The National Marine Fisheries Service (NMFS) has listed several anadromous fish species that do, or could potentially, exist in the watershed as threatened (Table 2.3). Coho salmon have been listed as threatened by NMFS. Coastal cutthroat and steelhead are candidates for listing. Listing for chum and chinook was not warranted as determined by NMFS. Listing occurs for an entire ESU. Coho salmon, coastal cutthroat, and Pacific lamprey are also listed as State Sensitive Species (ODFW 1997).

The Endangered Species Act (ESA) requires that forests providing habitat for endangered species must be protected. Relationships between land cover and the decline of rare species have been established. For example, loss of late successional forests may be related to declines in threatened and endangered species such as the northern spotted owl, marbled murrelet, and

Table 2.3. Peak live and dead fish counts for tributaries of the Necanicum River (Source: ODFW 2000).[1]

Tributary	Year		
	1996	1997	1998
Coho			
Bergsvik Creek	8	-	-
Joe Creek	4	-	3
Little Humbug Creek	4	4	-
SF Necanicum River	8	-	-
Chinook			
Bergsvik Creek	3	-	-
Joe Creek	3	-	-
Little Humbug Creek	2	1	-
SF Necanicum River	15	-	-
Steelhead[2]			
Bergsvik Creek	6	-	-
Joe Creek	4	-	9
Little Humbug Creek	3	2	-
SF Necanicum River	42	-	-

[1] These data do not include mainstem surveys and therefore may dramatically understate the abundance of wild winter steelhead, fall chinook, and chum salmon. The steelhead counts may represent almost exclusively early spawning hatchery steelhead recorded incidental to the process of completing coho surveys (W. Weber, retired, ODFW, pers. comm., March, 2002)

[2] Total live fish count used for this species

coho salmon (Garono and Brophy 1999, Tuchmann et al. 1996). An understanding of the land patterns associated with the distribution of these species can lead to a better understanding of how to conserve them.

Private, federal, and state owned lands have their own mandates for the protection and conservation of the habitats related to these threatened and endangered species. Private timber practices are regulated by the Forest Practices Act, which was designed to help protect important habitats. The ODF is developing an assessment and management plan to detail forest management practices within areas occupied by threatened species. Due to the complex interactions in watersheds, all of these practices must be considered on both public and private land in order to effectively manage the natural resources for the protection of the critical habitats associated with these species.

Background information on fisheries status is summarized below. Much of the following information was taken directly from ODFW's Biennial Report on the Status of Wild Fish in Oregon (ODFW 1995) or from the NMFS website (*http://www.nwr.noaa.gov*). A considerable amount of information specific to the Necanicum watershed was provided by Walt Weber, a retired ODFW fish biologist, and member of the Necanicum River Watershed Council.

2.4 Coho

2.4.1 Life History

The coho salmon (*Oncorhynchus kisutch*) is an anadromous species that rears for part of its life in the Pacific Ocean and spawns in freshwater streams in North America. Coho may spend several weeks to several months in fresh water before spawning, depending on the distance they migrate to reach their spawning grounds. All adults die within two weeks after spawning. Juveniles normally spend one summer and one winter in fresh water, although they may remain for one or two extra years in the coldest rivers in their range. They migrate to the ocean in the spring, generally one year after emergence, as silvery smolts about four to five inches long. Most adults mature at 3 years of age (ODFW 1995).

2.4.2 Listing Status (Source: *http://www.nwr.noaa.gov*).

Coho Salmon were listed as a threatened species on August 10, 1998 for the Oregon Coast ESU. The ESU includes all naturally spawned populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,606 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill. Coho salmon are listed as a State Sensitive Species statewide.

2.4.3 Population Status

Coho harvests during the 1800s and early 1900s in the north to mid-coast region (Columbia River to Siuslaw River) of the Oregon coast were primarily by gill net fleets that operated in the estuaries and lower river reaches. By the 1930s, an ocean troll fishery was well established. Coastal spawning ground counts did not begin until 1950. Total coho abundance, including harvested fish, was estimated for the north to mid-coast region by ODFW (1995) from historical

data such as cannery records and landing fees. Abundance estimates declined from 900,000 adults per year in 1890 to less than 200,000 adults per year in the 1950s and less than 40,000 adults per year in the 1990s.

Spawning ground survey data in the north to mid-coast gene conservation group have shown significant declines in coho abundance between 1950 and 1980 (McGie 1981). These population declines continued through the 1980s and 1990s. The decline in coastal coho productivity is illustrated by the trend in the ratio of offspring produced per spawner, calculated from peak counts. The pre-harvest recruits per spawner ratio declined an average of 7 percent per year for the brood years 1975 through 1991 (ODFW 1995).

Braided channels and marshes in the lower gradient reaches historically provided highly productive rearing areas for juvenile coho. Forested upland habitat provided favorable channel structure and temperature conditions. Historical coho populations sizes were also influenced by watershed size and gradient. Larger coho populations were found in the larger and lower gradient watersheds, and smaller populations were found in the smaller streams and in steep, high-gradient basins (ODFW 1995).

Gillnet catches from the Nehalem River alone totaled 150,000 fish in the 1930s (W. Weber, retired, ODFW, pers. comm., March, 2002), and therefore the ODFW (1995) estimate of 900,000 fish for the entire state may be too low. Anecdotal information on cannery records can provide some perspective. In the late 1890s, about 3,700 cases of salmon were canned at a Necanicum estuary cannery site. It appears most of the fish were coho salmon, although chum salmon were likely also canned. Some rough calculations by W. Weber (retired, ODFW, pers. comm., March, 2002) suggested that about 25,000 Necanicum River salmon were canned per year at that time. Assumptions made in this calculation include 48 one lb cans/case, a total fish weight of 68 lbs to produce 48 lbs of canned fish, and an average fish weight of 10 lbs. The first two assumptions are validated in Craig and Hacker (1940). In addition, during the mid 1800s, three tribes of native Americans would gather in the Necanicum estuary each fall to harvest salmon (Connolly 1992). This would also indicate the presence of substantial numbers of fish.

Population estimates based on intensive spawning surveys over the last 11 years (1990-2000) indicate an average spawning escapement of about 600 fish (ODFW spawning survey analysis). The range was 185 (1992) to 1135 (1991). Statisitcal confidence limits are quite wide. These estimates do not include any data from the Neawanna system, but do include fish

from the Ecola Creek watershed. Escapement data for 2001 will exceed 1200 fish (W. Weber, retired, ODFW, pers. comm., March, 2002).

A summary of wild coho salmon status for the North Coast District indicated that the coho salmon population was very depressed in the Necanicum River. Surveys in 1994-1995 along 12.2 miles of the Necanicum counted 88 fish, indicating that the Necanicum population was low, but well above 100, even in a very poor return year (Weber and Sheahan 1995). In poor return years, a number of survey reaches indicated no fish or peak counts of less than three fish per mile (ODFW Spawning Survey Reports). Little or no production is indicated when counts are that low, as the presence of both male and female fish is not guaranteed.

Numbers of adult coho (mostly age 3) escaping to the spawning grounds have been indexed using the peak count method, which is based on repeated counts on the spawning grounds. Peak count surveys were conducted by ODFW between 1981 and 2001. Cumulative counts and population estimates by watershed were compiled during the same period. Peak counts were relatively high in 1982, but since 1983 have remained low and variable (Figure 2.1). All-time lows were reached in 1997.

ODFW conducted eight random peak count surveys for coho salmon in the Necanicum River in 1998 and 12 surveys in 1999. The average adult coho peak count recorded per mile was 6.2 in 1998 and 3.7 in 1999.

Coho spawning surveys have been conducted throughout the Necanicum watershed for about 15 years. One standard survey, 1.5 miles of the upper Necanicum River, has been conducted longer than that. Other survey reaches are selected at random each year from a list of stream reaches that appear to provide potential for coho spawning.

ODFW estimated coast-wide coho spawner abundance for the 1999 spawning season. The estimate of adult coho spawners in the Necanicum River, Ecola Creek, and associated mid-size ocean tributaries was only 708 fish (± 344, 95 percent confidence interval). This constituted 8 percent of the estimate for the entire north coast region. The vast majority (91.5 percent) of the north coast coho were estimated to occur in the Nehalem River, Tillamook Bay, and Nestucca River drainages (ODFW 2000).

2.4.4 Factors Responsible for Decline

A combination of factors, including rearing and spawning habitat degradation, reduction in summer streamflow, passage impacts at dams and culverts, decrease in ocean productivity,

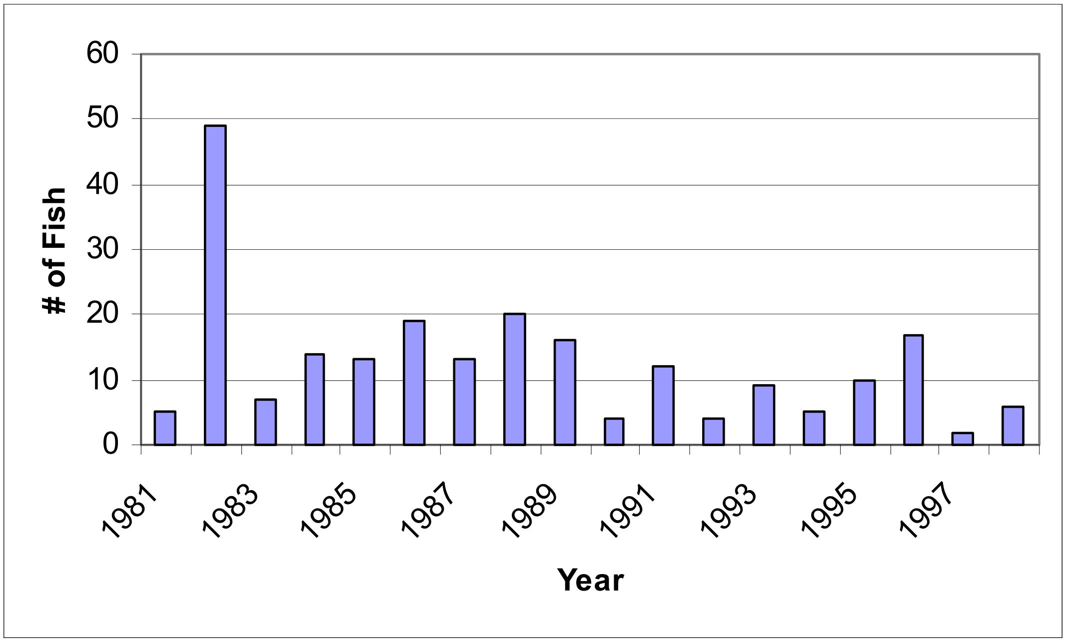


Figure 2.1. Peak count coho salmon data (number of fish counted) for the period 1981 through 1998 in the upper Necanicum River (Source: Weber and Sheahan 1995, ODFW 2000).

excessive fishing, and impacts caused by hatchery programs, have been implicated in most of the declines and extinctions of coho salmon populations in Oregon. Coho salmon evolved in freshwater ecosystems that were historically characterized by a high degree of structural complexity, including the presence of large woods, flood plains, braided channels, beaver ponds and, in some cases, lakes. Anthropogenic activities, including timber harvest, mining, water withdrawals, livestock grazing, road construction, stream channelization, diking of wetlands, waste disposal, gravel removal, farming, urbanization, and splash dam logging have altered most freshwater ecosystems. In the last 15 years, the productivity of the marine environment used by Oregon coho also has declined. Ocean productivity appears to have rebounded in 2000 and 2001. This decline in ocean productivity appears to have been part of a long-term, apparently natural cycle in ocean conditions that is outside of management influence. These decreases in freshwater and marine habitat condition coincided with several decades of increasing releases of hatchery coho salmon and sustained high harvest rates. Wild populations have declined, and the range of coho salmon in Oregon has contracted concurrent with these activities and processes (ODFW 1995).

Basic stream productivity has declined with declining spawning numbers. Historically, salmon carcasses were abundant and were trapped in abundant woody structures. Today we have neither abundant salmon carcasses nor woody structures. Salmon carcasses, eggs, and fry provided direct feeding opportunities for juvenile salmonids and aquatic invertebrates. Many forms of wildlife also utilized the carcasses and eggs. Key marine-derived nutrients such as nitrogen, carbon, and phosphorus stimulated the bottom of the food chain in the stream system (Cederholm et al. 1999).

In coastal rivers and lower Columbia Basin tributaries, low summer flows and the loss of complex in-stream structure, winter side channels, sloughs, and shade have been predominant problems. Timber harvest in the coastal temperate rain forest belt has contributed to winter habitat loss, particularly in the upper reaches of basins. Logging has caused the loss of large conifers from riparian areas that would have provided long-lasting in-stream structure when they fell into streams. Siltation from logging roads, road-failures, and loss of ground cover, along with reduction of water filtering and shade due to the removal of riparian vegetation, have reduced egg and juvenile survival. Historical logging practices also used splash dams that ripped spawning gravel and in-stream rearing structure out of streams when logs were flushed downstream as a form of transport. Agriculture, industrialization, and urbanization have degraded coho rearing habitat in the lower reaches and estuaries of many coastal streams through such actions as diverting water, channelizing streams, diking off-channel and estuary areas, and releasing effluents that elevate temperatures and reduce water quality (ODFW 1995).

Coho habitat impacts in north and mid-coast lowlands and estuaries have primarily been caused by agriculture, urbanization, and transportation. Braided lowland channels provided important, productive rearing areas. Many of these areas have been lost to diking, channelization, and draining of marshlands. The main land use along the upland reaches of north to mid-coast watersheds is timber harvest. Impacts to coho from timber harvest have been most severe on private lands, although forest practices have improved significantly since the passage of Oregon's Forest Practices Act. The most significant impacts are believed to have resulted from loss of large wood and old growth conifers in the riparian zone (ODFW 1995).

2.4.5 Species Distribution

ODFW mapped current coho distribution by attributing 1:100,000 stream coverages based on survey data, and best professional judgment of local fish biologists. The mapped

distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Coho salmon utilize as habitat the entire Necanicum River watershed, including all of the subwatersheds (Figure 2.2). Natural fish barriers are few and tend to occur in upper sections of small tributary streams. The Necanicum River watershed provides extensive coho habitat, although the coho population is small. Key production areas for the Necanicum likely include portions of Circle Creek, South Fork Necanicum, North Fork Necanicum, Bergsvik Creek, Joe Creek, and the upper Necanicum, based on cursory analysis of data from three recent years (1998-2000). Volunteer surveys of the Stanley Lake basin and Shangrila Creek indicate that these are also important production areas (W. Weber, retired, ODFW, pers. comm., March, 2002).

2.4.6 Hatcheries

Most current hatchery programs are designed to concentrate returning hatchery adults to traps where they can be captured and removed before they enter wild populations. All of the hatchery programs along the mid to north coast of Oregon are implemented for the purpose of providing fish for ocean harvest. Ocean harvest is a mixed-stock harvest, however, which includes wild, as well as hatchery fish. High harvest rates in the 1970s (above 75 percent, reaching 87 percent in 1976) were probably excessive for wild populations (ODFW 1995). Harvest rates on wild coastal coho declined substantially after the adoption of the Oregon Coastal Coho Management Plan in 1982.

Hatchery coho may have contributed to the decline of wild coho salmon, although there has not been a coho hatchery on the Necanicum River. Hatchery programs supported historical harvest rates in mixed-stock fisheries that were excessive for sustained wild fish production (TBNEP 1998). Hatchery coho have also strayed to spawn with wild fish, which may have reduced the fitness and therefore survival of the wild populations through outbreeding depression (Hemmingston et al. 1986; Flemming and Gross 1989, 1993; Hjort and Schreck 1982; Reisenbichler 1988), and which lowered effective population sizes (Ryman and Laikre 1991). Finally, hatcheries may have reduced survival of wild juveniles through increased competition for limited food in streams, bays, and the ocean in years of low ocean productivity,

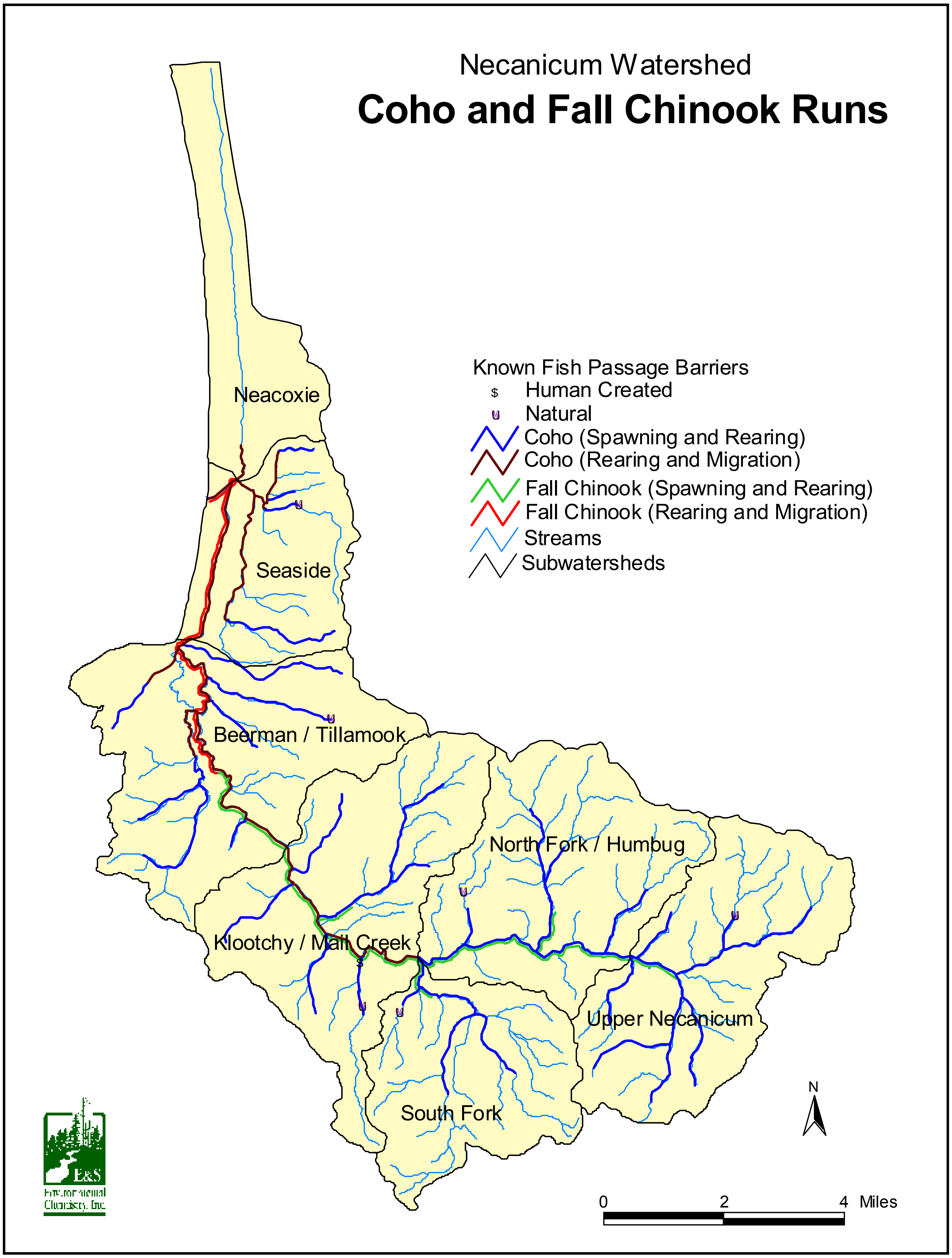


Figure 2.2. Coho and fall chinook distribution in the Necanicum River watershed (ODFW 2000). Coho are native, but fall chinook were introduced to this drainage.

through attraction of predators during mass migrations, and through initiation or aggravation of disease problems (Nickelson et al. 1986).

There have been no hatchery coho released in the Necanicum watershed since 1990. During the period 1978 through 1983, North Nehalem stock smolts (47,000 to 200,000) were released in four of those six years and North Nehalem stock presmolts (48,000 to 211,000) were released in three of those six years. During the period 1983 through 1990, eggs (23,000 to 294,000) of the same stock were provided to STEP volunteers for streamside incubator fry production. Stocking information after 1977 is from ODFW stocking records. Prior to 1978 there were some releases of Columbia River stock fry (pers. comm. to W. Weber, W. Knispel, ODFW biologist, 1950s-1991, March, 2002). Stocking records prior to 1978 are archived in the ODFW Clackamas office.

2.5 Coastal Cutthroat

2.5.1 Life History

Coastal cutthroat trout exhibit diverse patterns in life history and migration behaviors. Populations of coastal cutthroat trout show marked differences in their preferred rearing environments (river, lake, estuary, or ocean); size and age at migration; timing of migrations; age at maturity; and frequency of repeat spawning. Anadromous or sea-run populations migrate to the ocean (or estuary) before returning to fresh water. Anadromous cutthroat trout either spawn during the first winter or spring after their return or undergo a second ocean migration before maturing and spawning in fresh water. Anadromous cutthroat are present in most coastal rivers. Nonmigratory (resident) forms of coastal cutthroat trout occur in small headwater streams and exhibit little in-stream movement. They generally are smaller, become sexually mature at a younger age, and may have a shorter life span than many migratory cutthroat trout populations. Resident cutthroat trout populations are often isolated and restricted above waterfall barriers, but may also coexist with other life history types.

2.5.2 Listing Status (Source: *http://www.nwr.noaa.gov*).

On April 5, 1999, NMFS determined that listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due to concerns over specific risk factors. The ESU includes populations of coastal cutthroat trout in Oregon coastal streams south of the Columbia River and north of Cape Blanco (including the Umpqua River Basin,

where cutthroat trout were listed as an endangered species in 1996). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,606 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill. The coastal cutthroat is listed as a State Sensitive Species throughout its Oregon range.

2.5.3 Population Status

Less is known about the present status of sea-run cutthroat trout than about other anadromous salmonid species in the watershed. Sea-run cutthroat trout, the smallest of the anadromous salmonids present in the watershed, have not been fished commercially and are difficult to inventory. Although sea-run cutthroat trout are harvested in the recreational fishery, their numbers are not recorded on salmon/steelhead report tags. Therefore, determination of trends in abundance cannot be made on the basis of catch data. Beginning in 1997, sea-run cutthroat trout angling regulations were changed to "catch and release" only (TBNEP 1998). This change provided protection to not only adult sea-run fish, but also to presmolt and smolt life stages. Most sea-run cutthroat smolts and many of the rearing presmolts exceed the 8 inch minimum size limit that was in effect until 1997. Cutthroat trout spawn in small headwater tributaries in late winter and early spring when water conditions are generally poor for viewing. Age at spawning is highly variable (2 to 10 years) and individual adults may spawn more than once during their lifetime (Emmett et al. 1991).

Cutthroat trout populations are believed to be at very low levels in all North Coast District waters (Weber and Sheahan 1995). The status of the Necanicum River population is not known.

2.5.4 Factors Responsible for Decline

Coastal cutthroat trout tend to spawn in very small (first and second order) tributaries. Young fry move into channel margin and backwater habitats during the first several weeks. During the winter, juvenile cutthroat trout use low velocity pools and side channels with complex habitat created by large wood.

Very little is known about the habitat requirements and preferences of sea-run cutthroat trout in estuarine environments. Juvenile and adult cutthroat trout spend considerable time in tidal rivers and low-gradient estuarine sloughs and tributaries during spawning and feeding

migrations. Large wood likely is an important habitat component for cutthroat trout during their estuarine residence.

It appears that the lack of salmon carcasses in recent years may have had an adverse effect on stream productivity and cutthroat populations. Freshwater habitat problems may have serious consequences for cutthroat trout because of their lengthy freshwater residence (two to four years for anadromous fish and their complete life cycle for resident fish). They appear to remain near shore, probably near the mouth of their natal river, during their marine occupancy.

There are no consistent indicators of trends in abundance of sea-run coastal cutthroat trout. Based on creek surveys and fish counts at dams, however, ODFW has raised concerns that populations in Oregon may be experiencing widespread decline (ODFW 1995). In contrast, resident populations appear to remain relatively abundant, even in streams where sea-run populations have sharply declined. This suggests the impacts of problems that occur along migration corridors, in estuaries, and/or in near-shore environments (ODFW 1995). It appears that sea-run cutthroat may be particularly sensitive to adverse ocean conditions. Because of their localized estuary and ocean distribution, they are unable to avoid poor local ocean conditions. When such conditions reduce alternative prey species for larger predators such as marine mammals, cormorants, terns, and salmon, the cutthroat, from smolt to adult life stages, become major prey items. They seem to be an ideal size for such common predators as harbor seals and cormorants. At the same time, many of the cutthroat’s prey, such as juvenile anchovy, herring, and candlefish, may be in short supply (W. Weber, retired, ODFW, pers. comm., March, 2002).

2.5.5 Species Distribution

Sea-run cutthroat trout distributions have not been mapped by ODFW. However, ODFW identified populations of anadromous and resident cutthroat trout that use portions of the Necanicum River watershed. Resident populations exist in Beerman Creek above a waterfall at RM2, South Fork Necanicum River above numerous falls, Brandis Creek above a waterfall at RM0.5, Lindsley Creek above a waterfall at RM0.25, and Grindy Creek above a 50-foot waterfall (ODFW 1995). Anadromous cutthroat populations were identified in the mainstem Necanicum River.

2.5.6 Species Interactions

Cutthroat trout populations with different life history patterns may be sympatric in the same river. The level of genetic exchange between cutthroat trout of different life history types, for example, between sea-run and resident forms, is poorly understood (ODFW 1995). A single population may be polymorphic for several life histories; or the life histories may form separate breeding populations through assortative mating, but still exchange low levels of gene flow; or the life history types may form completely reproductively isolated gene pools. Extensive genetic and life history surveys will be needed to clarify these relationships.

Habitat use by juvenile cutthroat trout is affected by interactions with other salmonids, although the extent of the effect is poorly understood. It is known, however, that whereas juveniles prefer to rear in pools, young-of-the-year cutthroat trout may be displaced into low gradient riffles, particularly by the more dominant coho salmon. The selection of small tributaries for spawning and early rearing may help to reduce competitive interactions between cutthroat trout and steelhead trout or coho salmon. Differential selection of spawning habitat also may help to minimize hybridization with rainbow/ steelhead trout (ODFW 1995).

2.5.7 Hatcheries

Trout stocking was initiated in the Necanicum watershed during the late 1960s, but most of the early releases were rainbow trout from Willamette Valley hatcheries (pers. comm. to W. Weber, W. Knispel, ODFW, March, 2002). From 1978 through 1994, between 6,000 and 15,000 10-inch cutthroat smolts from Cedar Creek Hatchery (Alsea stock) were released (ODFW stocking records). Stocking records prior to 1978 are stored in the Clackamas office archives. The rainbow trout and cutthroat trout releases prior to about 1985 were designed to provide a “put and take” fishery in the spring. Returns of adult sea-run fish were regarded as an incidental bonus. With the realization that the adult fish were actually providing more recreation, the releases between 1985 and 1990 were changed to enhance adult returns. North Nehalem stock eggs (9,000 to 24,000) were provided to STEP volunteers with streamside incubators (ODFW stocking records). Stocking of cutthroat was discontinued in 1995, however, because of low returns to anglers and concerns regarding interactions with wild fish (Weber and Sheahan 1995).

2.6 Chum

2.6.1 Life History

The chum salmon is an anadromous species that rears in the Pacific and Arctic oceans and spawns in freshwater streams in North America. Most of the chum salmon life span is spent in a marine environment. Adults typically enter spawning streams ripe, promptly spawn, and die within two weeks of arrival. Most spawning runs are over a short distance, although exceptionally long runs occur in some watersheds in Asia and Alaska. Adults are strong swimmers, but poor jumpers and are restricted to spawning areas below barriers, including minor barriers that are easily passed by other anadromous species. Juveniles are intolerant of prolonged exposure to fresh water and migrate to estuarine waters promptly after emergence. A brief residence in an estuarine environment appears to be important for smoltification and for early feeding and growth. Movement offshore occurs when the juveniles reach full saltwater tolerance and have grown to a size that allows them to feed on larger organisms and avoid predators. Chum salmon mature at 2 to 6 years of age and may reach sizes over 40 pounds (ODFW 1995), although 20 pounds would be a trophy fish in Oregon.

2.6.2 Listing Status (Source: *http://www.nwr.noaa.gov*).

On March 10, 1998, NMFS determined that listing was not warranted for the Pacific Coast ESU. The ESU includes all naturally spawned populations of chum salmon from the Pacific coasts of California, Oregon, and Washington, west of the Elwha River on the Strait of Juan de Fuca. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,152 square miles in Oregon and Washington. The following counties lie partially or wholly within these basins: Oregon - Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill; Washington - Challam, Cowlitz, Grays Harbor, Jefferson, Lewis, Mason, Pacific, Thurston, and Wahkiakum. Chum salmon are classified as a State Sensitive Species throughout Oregon.

2.6.3 Population Status

Chum salmon populations have been very depressed on the Oregon side of the lower Columbia River. Some Washington streams (e.g., Grays River) along the lower Columbia have substantial populations of both hatchery and wild chum. Wild populations in Willapa Bay, just north of the Columbia River, appear to be very healthy. The Necanicum River has a sustaining

run of chum salmon, but it is very small. ODFW surveyed 25 percent of the chum salmon spawning habitat in the Necanicum watershed from 1991 through 1994. Numbers of live chum counted in the surveys ranged from a high of 172 fish in 1992 to a low of 15 fish in 1994 (Figure 2.3). Weber and Sheahan (1995) concluded that this population was barely holding. The spawning area and population of chum salmon in the Necanicum River are both small and unstable. ODFW (1995) concluded that the chum salmon population in the Necanicum is very vulnerable.

The most substantial populations of chum salmon in Oregon occur in Nehalem Bay, Tillamook Bay, Netarts Bay, and perhaps the Nestucca River. Monitoring in these areas has shown significant variability, but also a substantial decline during the 1950s, from which these populations have not recovered.

2.6.4 Factors Responsible for Decline

Chum salmon spawning habitat has been impacted in Oregon by siltation, channelization and gravel extraction. Siltation of spawning gravels has resulted from road construction, road failures, and logging. Access to historical spawning areas has been blocked by structures that continue to be passable by other anadromous fish, including tidegates, culverts, and gravel berms. Degradation of estuaries due to diking, water diversions, loss of marsh and cedar boglands, loss of estuary complexity, urbanization, and other actions has probably had a severe

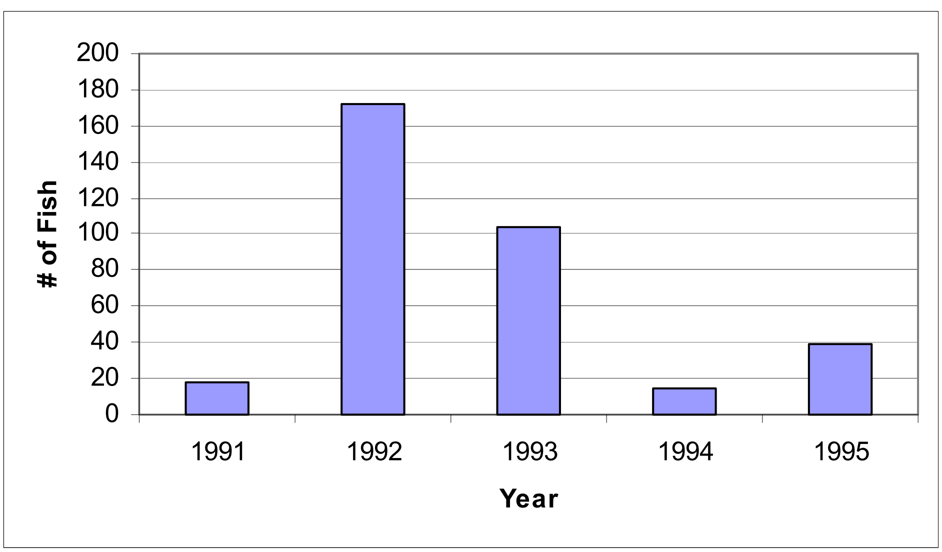


Figure 2.3. Chum counts for the period 1991 through 1995 (Source: ODFW 2000)

effect on chum salmon. The species in Oregon requires typical low gradient, gravel-rich, barrier-free freshwater habitats and productive estuaries (ODFW 1995).

Unstable gravel bars present an on-going problem for chum salmon in the Necanicum River. Urbanization impacts, such as rip rap, also pose a threat.

2.6.5 Species Distribution

ODFW mapped current chum distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Chum salmon use only the lower portions of the mainstem Necanicum River (Figure 2.4). Chum species in Oregon requires typical low gradient, gravel-rich, barrier-free freshwater habitats and productive estuaries.

2.6.6 Hatcheries

Oregon has never had a large chum salmon hatchery program, and there are currently no state hatchery programs for the species. One private hatchery has operated in the Nehalem estuary over the past few years. The objective at this hatchery has been to collect all returning hatchery adults, although some straying has occurred. Chum salmon are probably impacted by coho salmon hatchery programs that release large numbers of hatchery smolts into estuaries that are used by rearing juvenile chum. Coho salmon juveniles have been shown to be a major predator on chum juveniles in the Northwest (Hargreaves and LeBrasseur 1986). Juvenile chum salmon may also be affected by large releases of fall chinook salmon hatchery fish, particularly presmolts, since fall chinook juveniles also rear in estuaries and may compete with chum juveniles (ODFW 1995).

2.7 Steelhead

2.7.1 Life History

Necanicum River steelhead are winter-run fish; summer steelhead in Oregon are present only in a few large watersheds. The subspecies (*Oncorhynchus mykiss irideus*) includes a resident phenotype (rainbow trout) and an anadromous phenotype (coastal steelhead). Steelhead

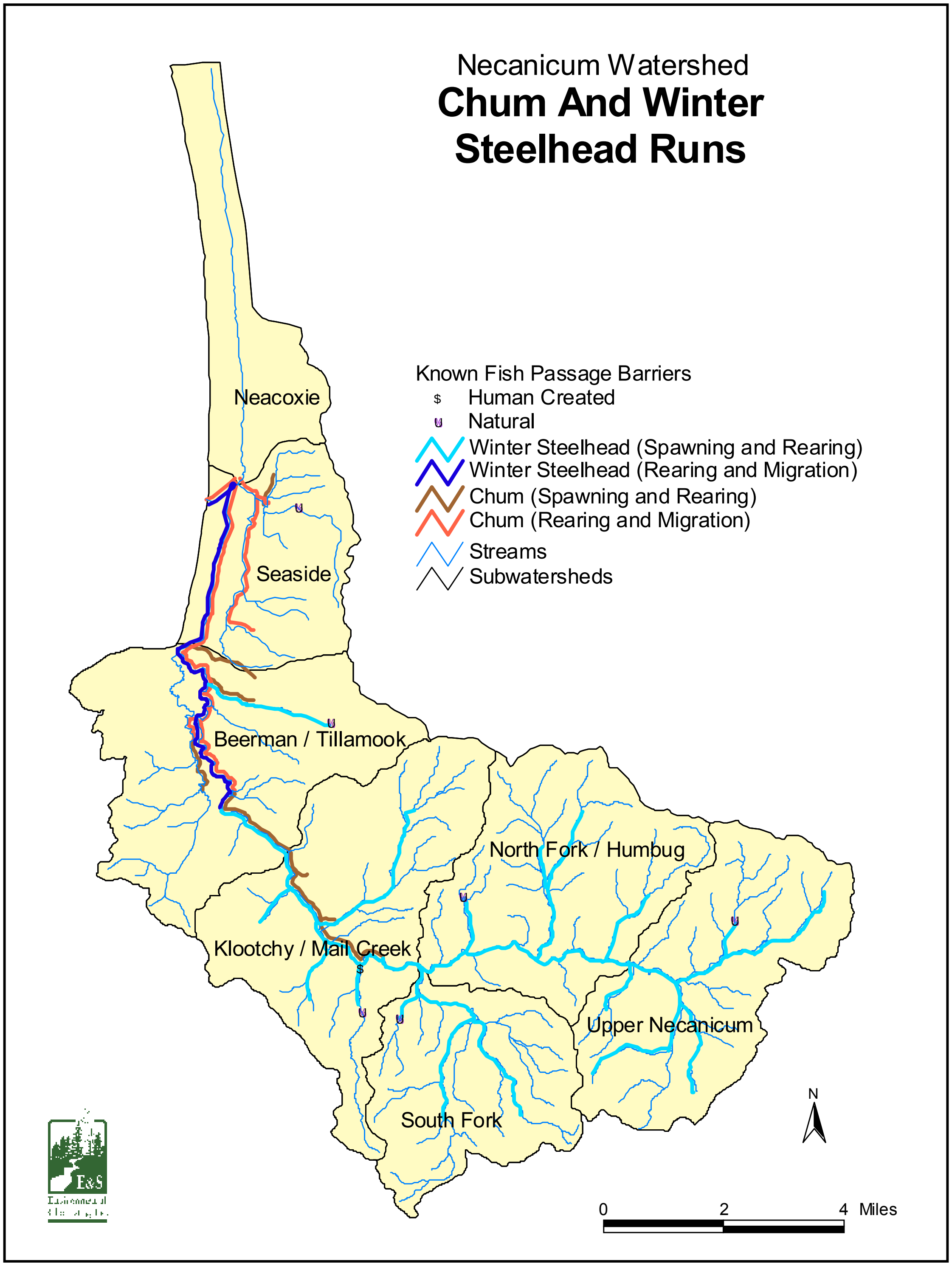


Figure 2.4. Chum salmon and winter steelhead distribution in the Necanicum River watershed (ODFW 2000).

express a further array of life histories, including various freshwater and saltwater rearing strategies and various adult spawning migration strategies. Juvenile steelhead may rear one to four years in fresh water prior to their first migration to salt water. Saltwater residency may last one to three years. Adult steelhead may enter fresh water on spawning migrations year round if habitat is available for them, but generally spawn in the winter and spring. Both rainbow and steelhead may spawn more than once. Steelhead return to salt water between spawning runs. Relatively few (approximately 10 percent, mostly females) are successful in making a second spawning migration. Winter steelhead generally enter streams from November through May and spawn soon after entering freshwater. Age at the time of spawning ranges from 2 to 7 years with the majority returning at ages 4 and 5 (Emmett et al. 1991).

2.7.2 Listing Status (Source: *http://www.nwr.noaa.gov*).

On March 19, 1998, NMFS determined that listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due the fact that hatchery fish heavily supplement many of the runs and that survival of both wild and hatchery fish has declined recently (Busby et al. 1996). The ESU includes steelhead from Oregon coastal rivers between the Columbia River and Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.7.3 Population Status

No reliable information on the historic abundance of steelhead in the Necanicum River watershed is available. Rough estimates of total coastwide steelhead run size made in 1972 and 1987 were similar (Sheppard 1972, Light 1987), suggested that overall abundance may have remained relatively constant during that period. However, the proportion of hatchery fish in the run appeared to have increased between the two estimates. Light (1987) estimated total run size for the major stocks on the Oregon Coast for the early 1980s at 255,000 winter steelhead and 75,000 summer steelhead. With about 69 percent of winter and 61 percent of summer steelhead of hatchery origin, Light estimated that the naturally-produced runs totaled only 79,000 winter and 29,000 summer steelhead (note that most of the Oregon coastal summer steelhead are in the Umpqua and Rogue River systems; TBNEP 1998).

Based on abundance estimates from salmon-steelhead punch cards, steelhead populations in Oregon coastal streams outside the mid-coast region appear to have experienced a mild decline in recent years (ODFW 1995). This decline was probably due in part to low ocean productivity. Activities within the watersheds have also contributed to further impacts to individual populations.

Winter steelhead spawning surveys were conducted by volunteers, trained by Rainland Fly Caster, on the Necanicum River from 1998 to 2000. ODFW protocols were followed. Survey reaches were from the mouth of the South Fork upstream to the pool above Lindsley Creek (about 1.1 miles) and the Upper Necanicum River from the Highway 26 Bridge to Longview Fibre Bridge (about 1.5 miles). Limited survey work was also done on Bergsvik Creek in 1998, but no redds were found. Survey results are shown in Table 2.4. Surveys were done from mid-March through the end of the spawning season in late May. This timing insured that these counts included only wild fish. A healthy wild steelhead population is indicated. ODFW studies on redd numbers per known number of fish suggests that each redd represents about two fish (ODFW Research Division studies, 1999). There is likely additional spawning habitat similar to that of the most productive spawning area (middle Necanicum) surveyed. A spawning population of at least 1000 fish is therefore likely (W. Weber, retired, ODFW, pers. comm., March, 2002). It appears that nearly all of the wild fish spawning takes place in the mainstem. Much of the hatchery spawning occurs in the tributaries (ODFW Research Division study, 1996).

Weber and Sheahan (1995) summarized steelhead population status in the ODFW North Coast Fish District. The steelhead population in the Necanicum River was judged to be small,

Table 2.4. Results of winter steelhead spawning surveys conducted by volunteers during the period 1998 to 2001.[1]

	2001	2000	1999	1998
Mouth of South Fork to pool above Lindsley Creek (1.1 miles)				
Redds	58	93	64	111
Fish	11	43	24	5
Upper Necanicum (1.5 miles)				
Redds	11	8	13	23
Fish	3	0	0	1

[1] Data provided by W. Weber (retired, ODFW, pers. comm., March, 2002)

heavily impacted by habitat deterioration, and occupied by hatchery fish. However, the more recent and extensive spawning surveys detailed above indicate that the wild steelhead population in the Necanicum River is in better shape than previously thought (W. Weber, retired, ODFW, pers. comm., March, 2002).

2.7.4 Factors Responsible for Decline

Coastal steelhead abundance follows a similar cycle in all populations from Puget Sound in Washington to California, indicating that factors common to all populations influence trends. The most probable factor responsible for this cycle is ocean condition. Ocean productivity is recognized to undergo long-term cycles that include periods that are relatively favorable or unfavorable to the survival of salmonids. This cycle appears to be a natural process that cannot be affected by management actions. The ocean productivity cycle appears to have been unfavorable for steelhead recently and all steelhead population abundance trends have been correspondingly low (ODFW 1995).

Steelhead and rainbow trout populations have also been affected by freshwater habitat degradation. Most coastal salmonid freshwater habitats were historically coniferous, temperate, rain forest ecosystems. Stream systems were structurally complex, with large in-stream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs. Human activities have altered these ecosystems, particularly by reducing their complexity and removing components that were essential to steelhead and rainbow trout production. Logging and road construction in the Coast Range and Cascade Mountains have had the most widespread impact on coastal steelhead, and have affected most populations. Habitat degradation has occurred in response to stream siltation, loss of structural complexity, and loss of riparian cover from logging and road building, agricultural practices, stream channel alterations, water withdrawals, and urban and rural development. The lack of salmon carcasses and the related adverse impact on stream productivity may also have a limiting effect on steelhead populations. Because of their lengthy (typically two years) freshwater juvenile rearing period, steelhead are more impacted by adverse freshwater habitat conditions than salmon species.

Angling regulations that permitted the retention of wild steelhead may have contributed to declines in steelhead populations. Since 1992, regulations on the Necanicum and most other Oregon waters have required the release of wild steelhead. Hatchery fish are identified by a clipped adipose fin.

2.7.5 Species Distribution

ODFW mapped current steelhead distribution by attributing 1:100,000 stream coverages based on survey data, and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. Theses coverages are scheduled to be updated every two years, and are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Winter steelhead use much of the Necanicum River watershed (Figure 2.4). As noted earlier, the hatchery fish seem to spawn in the tributaries and the wild fish are mainstem spawners. This species prefers larger, structurally complex streams with relatively high gradient, boulder/cobble substrate, large in-stream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs.

2.7.6 Hatcheries

Coastal steelhead hatchery programs are present along the coast and in the lower Columbia and Willamette basins. These programs historically depended on two broodstocks. The Alsea winter steelhead hatchery stock was founded from wild steelhead in the Alsea River on the mid-coast. This stock has been outplanted into most coastal basins. In spite of this widespread outplanting of a single broodstock, Oregon's wild coastal steelhead populations have not been "homogenized" like those described by Reisenbichler and Phelps (1989) in Puget Sound. This is demonstrated by the high level of genetic variation that is still present among steelhead populations along the Oregon coast (Hatch 1990, Reisenbichler et al. 1992). Alsea steelhead are now being planted in fewer locations and local broodstocks are being developed in many of the basins (ODFW 1995).

Steelhead stocking was initiated in the mid-1960s, using Alsea River stock smolts (pers. comm. to W. Weber, W. Knispel, ODFW, March, 2002). Beginning in 1979, some of the smolts were from North Nehalem stock and by 1987 this was the only stock utilized. Since 1978, stocking levels have been between 24,000 and 62,000. In recent years, eggs were furnished to streamside incubators operated by STEP volunteers. Numbers ranged from 23,000 to 221,000. Stocking data since 1978 are found in ODFW stocking reports. Earlier stocking details are archived in files at the ODFW Clackamas office.

The current steelhead stocking program may be out of compliance with ODFW's Wild Fish Policy, which was adopted in the late 1980s (W. Weber, retired, ODFW, pers. comm., March, 2002). This policy is currently in the process of being modified. An intensive spawning fish

capture program was completed in 1996 by ODFW Research Division crews. The object was to look at wild/hatchery fish interaction on the spawning grounds. January, February, and early March observations indicated a very high percentage of hatchery fish spawning with relatively few wild fish. Observations beginning in late March indicated a much lower percentage of hatchery fish. The Wild Fish Policy goal was to have only a low percentage of hatchery fish spawning with wild fish. Resolution of this issue is troublesome because of the high hatchery fish numbers and escapement, the difficulty in keeping hatchery fish off the spawning beds, the presence of viable numbers of wild fish, and the popularity of the fishery.

There has been a high-intensity winter steelhead fishery on the Necanicum River targeted on the hatchery fish. The Necanicum continued to produce viable numbers of wild or unmarked fish in spite of the presence of large numbers of hatchery spawners (Weber and Sheahan 1995).

2.8. Chinook

2.8.1. Life History

Oregon chinook salmon populations exhibit a wider range of life history strategies than coho or chum salmon, with variation in the date, size and age at juvenile ocean entry; in ocean migration patterns; and in adult migration season, spawning habitat selection, age at maturity and size (Nicholas and Hankin 1989; Healey 1994). Generally, subyearling juveniles rear in coastal streams from three to six months and rear in estuaries from one week to five months. Nearly all Oregon coastal chinook salmon enter the ocean during their first summer or fall (ODFW 1995). Mature fall chinook (2 to 6 years of age) return from the ocean from late October through early January. Peak entry into the rivers occurs in late October and November.

Chinook generally spawn in large tributaries and mainstem reaches. They select larger substrate and bury their eggs deeper than other anadromous species. It is thought that chinook smolts spend considerable time in estuarine areas before moving to the ocean. Trask River stock chinook, which are found in this watershed, return anywhere from two to six years of age. Returns at age three or four are the most common life histories.

Spawning chinook salmon in Oregon's small coastal streams tend to concentrate in high densities on gravel bars in specific river reaches. Fall chinook adults may move directly to the spawning bars after river entry, but spring chinook adults require deep, cold holding pools reasonably near spawning areas where they hold and mature for four to six months prior to spawning. This holding period occurs during the summer when flows are naturally lowest and

water temperatures are warmest. Fall chinook are more restricted by minor migration barriers such as culverts or berms than are coho or steelhead. Habitat alterations that affect the abundance, stability and accessibility of mainstem gravel bars impact all chinook.

Coastal juvenile chinook salmon rear for several months during their first spring in lower river mainstems, using deep riffles, woody debris and shoreline riparian vegetation for cover and feeding areas. Juveniles move into estuaries generally by late June or July where they continue rearing through the summer. Most chinook juveniles in populations along the central coast enter the ocean in the fall. Lower basin habitat complexity, summer flows, and estuary productivity affect rearing chinook salmon.

2.8.2 Listing Status

Fall chinook salmon were not native to the Necanicum watershed and were introduced through a stocking program. Oregon coastal fall chinook stocks are considered generally healthy. Table 2.1 indicates that they are not listed and are not a candidate species. Oregon has not identified them as a State Sensitive Species.

2.8.3 Population Status

Poor returns were observed following the initial years of stocking (mid 1970s) and it was thought that the small Necanicum watershed estuary might be a limiting factor. Successful returns were observed after smolt stocking terminated (1982) and a smolt stocking program was reinstated (1989). Adequate returns have been observed every year since, even though there were several years in which no fry or smolts were stocked. The varied life history of chinook salmon masks the impacts of a poor production year. It is unclear to what extent natural production is complementing the stocking program. ODFW does not have a program to estimate chinook escapement or population levels but extensive counts are obtained incidental to coho salmon surveys. However, these surveys do not cover prime mainstem chinook spawning habitat.

2.8.4 Factors Responsible for Decline

The causes of declines of some chinook salmon populations vary substantially for different regions of the state, depending largely on human-related changes to each watershed, and also upon ocean migration routes used by different populations. Populations of far north-migrating

wild fall chinook in north coastal rivers appear to be stable or increasing, largely due to their migration into an area where ocean conditions generally have been favorable for at least a decade, to improvements in mainstem spawning habitat in some rivers, and to decreases in ocean harvest rates as a result of annually-negotiated fishing regimes under the Pacific Salmon Treaty between the United States and Canada (ODFW 1995).

There is no information available that is specific to the Necanicum River watershed regarding environmental changes that may have adversely affected the quality of chinook habitat. General information regarding such issues is summarized below.

Freshwater habitat alterations that have impacted chinook salmon along the mid- to north Oregon coast have primarily been associated with historical logging practices, fires, and storm-driven erosional events that deforested, channelized, scoured, and destabilized mainstem spawning areas. Logging and agricultural practices, and urban development also decreased the complexity and productivity of lower mainstem reaches and estuaries. In many areas, impacts due to natural winter storm events have increased due to riparian deforestation, stream channelization, and bank destabilization. Agricultural and logging practices along low gradient river reaches in lower basins have greatly decreased the complexity and productivity of juvenile chinook rearing areas. Wetlands, marshes and braided channels have been straightened, channelized, diked, drained and deforested to create croplands and pastures. Summer flows and water quality have also decreased and summer water temperatures have increased in these areas. Many wetlands adjacent to estuaries have been diked, filled or drained to provide land for development. Many of the estuaries associated with urban centers have also been dredged and jetties have been constructed to provide boat access.

2.8.5 Species Distribution

Most of the mainstem and the lower reaches of the larger tributaries are used by spawning adults (Figure 2.2).

2.8.6 Hatcheries

Releases of fall chinook started in the mid 1970s and continues today. The current target for fall chinook smolt releases in the Necanicum watershed is 25,000 fish. However the actual number varies from year-to-year depending on the size of the return. There is no hatchery in the Necanicum watershed. However, a Salmon Trout Enhancement (STEP) program which

partnered up with local citizens to incubate, rear and release fall chinook in the watershed was active until recently.

Trask River stock smolts were initially released through 1981. Releases from 1978 through 1981 ranged from 71,000 to 109,000. Stocking was terminated because of initial poor returns. When successful returns showed up from the last few releases, the program was restarted with a release of 127,000 presmolts in 1989. STEP volunteers started an egg to smolt program in a backwater rearing pond and operated that for three years. Releases ranged from 10,000 to 24,000. About 25,000 hatchery-reared smolts have been released since 1996.

From 1985 to the present, STEP has operated streamside incubators and was provided egg numbers ranging from 9,000 to 292,000. Citizen interest in the program has waned, and currently there is only one volunteer incubating fish (J. Sheahan, 2002, pers. comm.). Egg numbers in recent years have been about 15,000.

As noted above, there have been several breaks in both the smolt and egg stocking programs. Stocking data beginning in 1978 are from ODFW stocking records. Detailed stocking data prior to 1978 are archived in the Clackamas ODFW office. The proposed closure in 2002 of the Trask River Hatchery could end this stocking program.

2.9 Pacific Lamprey

2.9.1 Life History

Pacific lamprey are anadromous and dig a redd in gravel substrate to cover their eggs. The fish construct the redds one rock at a time, using their suction mouths to grasp each rock. Redds are first observed in the Necanicum in early April; peak spawning activity is seen in late April and continues until at least late May. ODFW Research Division staff recorded similar timing in a 1999 coast-wide survey (ODFW Research Div. report, W. Weber, retired, ODFW, pers. comm., March, 2002). Adult lamprey spend a full year in the stream before spawning. They apparently do not feed during this period. After the eggs hatch into juveniles, called ammocytes, they spend an unknown number of years in the stream before emigrating to the sea. They apparently spend most of their stream residence time buried in silty substrate areas. At no time while they are in fresh water are they parasitic, as they are in the ocean.

2.9.2 Listing Status

Pacific lamprey have not been considered for listing by the National Marine Fishery Service. Oregon has identified them as a State Sensitive Species.

2.9.3 Population Status

There is a growing concern that Oregon populations of Pacific lamprey are in decline. It is also speculated that these populations are subject to sharp swings for no apparent reason. The Rainland Fly Caster steelhead survey teams have recorded lamprey redd and fish numbers during the Necanicum watershed surveys. These data are shown below in Table 2.5.

It appears that some of the spawning activity in this reach is due to brook lamprey. However, the numbers do seem to parallel those observed in the lower reach where no brook lamprey have been observed.

2.9.4 Factors Responsible for Decline

Causes for the apparent decline are poorly understood. Events or activities that create adverse impacts on the salmon egg survival would also be expected to impact lampreys.

2.9.5 Species Distribution

Information is limited to what has been observed on the steelhead spawning surveys.

Table 2.5. Pacific lamprey redd and fish numbers recorded by volunteers during Necanicum watershed surveys in 1998 through 2001.[1]

	2001	2000	1999	1998
Mouth of South Fork to pool above Lindsley Creek (1.1 miles)				
Redds	25	24	54	185
Fish	1	4	4	35
Upper Necanicum (1.5 miles)				
Redds	5	14	43	88
Fish	0	0	1	0

[1] Data provided by W. Weber (retired, ODFW, pers. comm., March, 2002)

CHAPTER 3. AQUATIC AND RIPARIAN HABITATS

3.1 Introduction

Distribution and abundance of salmonids within the watershed varies with habitat conditions such as substrate and pool frequency and biological factors such as food distribution (i.e. insects and algae). In addition, salmonids have complex life histories and some use different portions of the watershed during different parts of their life cycle. For example, salmonids need gravel substrates for spawning, but may move to different stream segments during rearing. There are also differences among salmonid species in their timing and extent of habitat utilization. The interactions of these factors in space and time make it difficult to identify the specific watershed components that most strongly affect salmonid populations. Consequently, entire watersheds must be managed to maintain fish habitats, and not just individual components (Garono and Brophy 1999).

Understanding the spatial and temporal distribution of key aquatic habitat components is the first step in learning to maintain conditions suitable to sustain salmonid populations. These components must then be linked to larger scale watershed processes that may control them. For example, a stream that lacks sufficient large woody debris (LWD) often has poor LWD recruitment potential in the riparian areas of that stream. By identifying this linkage, riparian areas can be managed to include more conifers to increase LWD recruitment potential. Also, high stream temperatures can often be linked to lack of shade as a result of poorly vegetated riparian corridors. By linking actual conditions to current watershed-level processes, land managers can better understand how to manage the resources to maintain these key aquatic habitat components.

Healthy populations of anadromous salmonids are generally associated with the following freshwater habitat characteristics:

- cool, clean, well oxygenated water;
- unobstructed access to spawning grounds;
- clean, stable spawning gravel;
- winter refuge habitat for juveniles;
- complex stream channel structure with an appropriate mixture of riffles, pools, and glides;
- deep pools;
- stream channels with an abundant supply of large woody debris;

- abundant food supply;
- adequate summer stream flows; and
- diverse, well-established riparian community.

Barber et al. (1994) provided a model for guiding habitat restoration work for salmonid fish (especially coho salmon) along the northern Oregon coast. Potential restoration sites were identified, along with source areas, which were defined as strongholds that would be expected to restock restoration sites in the various subbasins. The identified source areas within the Necanicum watershed were as follows:

<u>coho salmon</u> - Upper Necanicum River from RM16 approximately 4 miles upstream to the point where the gradient becomes steep enough that it is no longer considered prime coho habitat; low-gradient portions of tributary streams were also included

<u>steelhead</u> - South Fork Necanicum River, from RM13 approximately 2.2 miles upstream to barrier, including low gradient portions of tributary streams

<u>chum salmon</u> - Lower mainstem Necanicum River from head of tide (RM4) upstream approximately 11 miles to the mouth of the South Fork Necanicum River

Recommended in-stream habitat restoration work for improving coho salmon production emphasizes increasing habitat complexity and the availability of in-stream and off-channel over-wintering habitat (Barber et al. 1994). Such efforts, while often directed at coho habitat improvement, are also expected to increase production of steelhead and cutthroat smolts.

Sites recommended by Barber et al. (1994) for coho habitat restoration were generally those that had low probability for sediment problems, low amounts of LWD, almost no keystone pieces of LWD (24 in. diameter and length at least equal to channel width), and pools with insufficient depth and complexity. Such sites lacked off-channel, alcove and lateral habitats and had riparian vegetation dominated by red alder, with few large conifers. This kind of site often has good potential for habitat improvement.

Barber et al. (1994) recommended restoration sites for improvement of coho and steelhead habitat along the lower reaches of Klootchy Creek and Bergsvik Creek, in both cases just upstream of their confluence with the mainstem Necanicum River.

3.2 Aquatic Habitat Data

To assess current habitat conditions within the Necanicum River watershed, we have compiled fish habitat survey data collected according to the ODFW protocol (Moore et al. 1997). Stream survey data provide a snapshot in time of stream conditions. However, streams are dynamic and channel conditions may change drastically from year to year, depending on climatic conditions. Nevertheless, these data are useful in describing the current status or suggesting the existence of trends in habitat conditions that may be linked to larger watershed processes. Through development of an understanding of habitat distribution patterns, land managers can identify and address problem areas.

To interpret the habitat survey data, ODFW has established statewide benchmark values as guidelines for an initial evaluation of habitat quality (Table 3.1). The benchmarks rate conditions as desirable, moderate, or undesirable in relation to the natural regime of these streams. These values depend upon climate, geology, vegetation and disturbance history, and can help to identify patterns in habitat features that can lead to a better understanding of the effects of watershed processes on the current conditions of the stream channel.

ODFW has conducted stream habitat surveys throughout the Necanicum River watershed, totaling approximately 19 percent of the entire stream network (Figure 3.1). The large flood event of 1996 most likely altered LWD conditions in the watershed and probably introduced some new LWD to the stream network. However, stream channels still lack LWD in general. The condition of LWD in the system is dynamic, and while watershed-scale assessments can provide information useful for prioritizing restoration activities, all sites should be field- verified before specific restoration actions are planned.

3.2.1 Stream Morphology and Substrates

Stream morphology describes the physical state of the stream, including features such as channel width and depth, pool frequency, and pool area (Garono and Brophy 1999). Pools are important features for salmonids, providing refugia and feeding areas. Substrate type is also an important channel feature since salmonids use gravel beds for spawning. These gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat. For streams that were surveyed, stream morphology and substrates were compared against ODFW benchmarks to evaluate current habitat conditions.

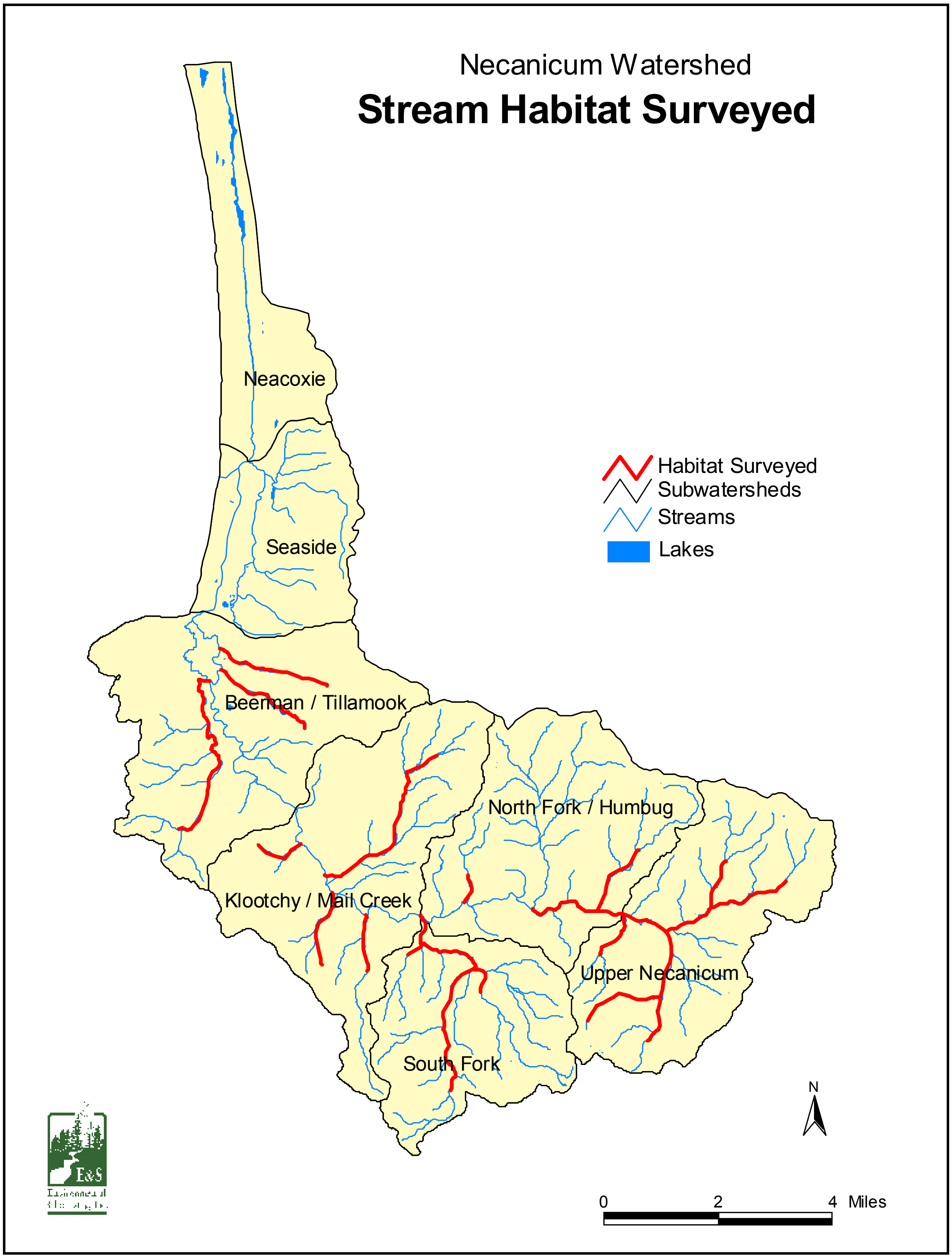


Figure 3.1. Streams surveyed for habitat conditions by ODFW.

Table 3.1. ODFW Aquatic Inventory and Analysis Habitat Benchmarks.

	Undesirable	Desirable
Pools		
Pool Area (percent total stream area)	<10	>35
Pool Frequency (channel widths [m] between pools)	>20	5-8
Residual Pool Depth (m)	<0.2	>0.5
Riffles		
Gravel (% area)	<15	$35
Large Woody Debris		
Pieces (per 100 m)	<10	>20
Volume (m^3 per 100 m)	<20	>30
"Key" Pieces (>60 cm dia. and >10 m long per 100 m)	<1	>3
Shade (reach average %)	<60	>70
Riparian Conifers (30 m from both sides)		
Number > 20-in dbh/1,000-ft stream length)	<150	>300
Number > 35-in dbh/1,000-ft stream length)	<75	>200

In the streams surveyed, the pool frequency for the majority (59 percent) of the pools fell in the moderate category. The remainder of the surveyed stream reaches were in the desirable category. The majority (62 percent) of the stream reaches were also in the moderate category based on the percent of area of the stream reach in pools. However, 12 percent of the surveyed streams were rated undesirable for percent pools (Table 3.2). In general, the depth of pools was moderate. Residual pool depth was desirable for 16 percent of all stream reaches surveyed. None of the surveyed streams had undesirable residual pool depths.

Gravel beds are important channel features since they provide spawning areas for salmonids. Gravel conditions in riffles demonstrated generally desirable conditions, although Bergsvik Creek and South Fork Necanicum River showed moderate conditions in all reaches surveyed (Table 3.2).

3.2.2 Large Woody Debris

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains a small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000; BLM

Table 3.2. Stream morphology and substrate conditions in the Necanicum River watershed as compared to ODFW benchmark values. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW.

Stream	Reach	Stream Miles	Gradient (%)	Pool Frequency (Channel Width Between Pools)	Percent Pools	Residual Pool Depth (m)	Gravel in Riffles (%area)
Beerman Creek	1	1.8	1.5	5.0	39.7	0.5	61.0
	2	0.9	2.7	6.7	17.6	0.3	29.0
Bergsvik Creek	1	1.5	1.1	4.2	64.2	0.5	34.0
	2	1.2	1.8	5.2	52.9	0.4	32.0
Brandis Creek	1	0.5	4.8	16.8	9.6	0.3	40.0
Circle Creek	1	2.9	0.4	9.2	15.7	0.5	55.0
	2	1.1	2.0	4.4	41.9	0.5	54.0
	3	0.7	2.5	10.9	16.9	0.3	34.0
Grindy Creek	1	1.0	3.0	6.5	31.5	0.4	41.0
Johnson Creek	1	0.8	3.5	3.4	27.6	0.3	52.0
	2	0.5	7.9	8.2	8.0	0.2	28.0
Klootchy Creek	1	2.5	2.6	3.7	31.3	0.4	42.0
	2	1.3	5.8	2.5	21.0	0.3	40.0
Lindsley Creek	1	0.6	6.8	6.2	10.9	0.2	40.0
Little Humbug Creek	1	0.9	2.6	3.7	30.3	0.5	42.0
	2	0.8	5.5	5.0	19.1	0.4	31.0
Little Joe Creek	1	1.5	6.4	8.2	14.8	0.4	53.0
Mail Creek	1	1.0	3.3	5.5	29.9	0.4	52.0
South Fork Necanicum R., Trib a	1	0.8	6.0	4.0	19.3	0.4	23.0
	2	1.1	4.2	9.0	6.6	0.5	18.0
	3	0.6	5.8	4.6	7.7	0.3	18.0
South Fork Necanicum River	1	1.3	2.0	5.4	30.8	0.7	18.0
	2	0.9	2.9	5.8	31.3	0.6	31.0
Upper Necanicum River	1	1.7	1.4	2.8	50.1	0.6	45.0
	2	0.9	1.5	5.6	39.2	0.8	44.0
	3	0.8	2.5	3.9	28.6	0.6	48.0
	4	1.9	3.3	6.9	21.8	0.4	51.0
Volmer Creek	1	0.9	2.6	5.1	33.5	0.4	46.0
	2	0.9	4.5	10.2	19.1	0.3	30.0
Warner Creek	1	1.0	2.9	3.5	32.5	0.3	35.0
Williamson Creek	1	0.7	1.6	5.0	61.7	0.2	44.0
	2	0.6	2.6	9.5	74.1	0.3	36.0
= Desirable			= Undesirable			= Moderate	

1996). LWD is most abundant in intermediate sized channels in third- and fourth-order streams. In fifth-order and larger streams, the channel width is generally wider than the length of a typical piece of LWD, and therefore, LWD is not likely to remain stable in the channel. In wide channels, LWD is more likely to be found along the edge of the channel.

In general, LWD conditions in the surveyed streams were undesirable. In particular, the density of key pieces of LWD was rated as undesirable in all surveyed stream reaches (Table 3.3). The volume of LWD was also almost always rated as undesirable, with very few stream reaches in the moderate category. LWD conditions in the watershed as a whole were exceptionally poor overall, having consistently undesirable LWD conditions in most reaches in terms of the total number of pieces, the volume of the pieces, and the number of key pieces per 100 m of stream. Riparian conditions uniformly demonstrated undesirable conditions, with all streams lacking sufficient densities of conifers in the riparian zones (Table 3.4). Similarly, most of the streams showed poor LWD recruitment potential (Table 3.5).

3.2.3 Shade

Shade conditions in the streams surveyed were generally rated as desirable. Only the Upper Necanicum River subwatershed showed a significant proportion of less-than-desirable shade conditions (Table 3.4). However, riparian conifer conditions were undesirable in all reaches, suggesting that much of the shading is provided by hardwood species such as alder and maple. These relatively short-lived hardwoods do not contribute high quality LWD to the stream system.

3.3 Riparian Conditions

The riparian zone is the area along streams, rivers and other water bodies where there is direct interaction between the aquatic and terrestrial ecosystems. The riparian zone is one of the most highly valued and threatened ecosystem elements in the United States (Johnson and McCormick 1979, Kauffman et al. 1997). It provides bank stability, controls erosion, moderates water temperature, provides food for aquatic organisms and large woody debris to increase aquatic habitat diversity, filters surface runoff to reduce the amount of sediments and pollutants that enter the stream, provides wildlife habitat, dissipates flow of energy, and stores water during floods (Bischoff et al. 2000). In addition, it is the primary source of large woody debris for the

Table 3.3. Large woody debris conditions in the Necanicum River watershed as compared to ODFW habitat benchmark values. Data were collected by ODFW.

Stream	Reach	Stream Miles	Gradient (%)	Woody Debris # Pieces/ 100m	Woody Debris Vol. (m^3/100m)	Woody Debris # Key Pieces / 100m
Beerman Creek	1	1.8	1.5	2.1	2.0	0.0
	2	0.9	2.7	6.7	11.4	0.0
Bergsvik Creek	1	1.5	1.1	5.7	12.9	0.0
	2	1.2	1.8	10.5	24.9	0.0
Brandis Creek	1	0.5	4.8	9.6	6.3	0.0
Circle Creek	1	2.9	0.4	4.5	7.4	0.0
	2	1.1	2.0	8.2	24.5	0.0
	3	0.7	2.5	5.5	6.2	0.0
Grindy Creek	1	1.0	3.0	7.3	16.1	0.0
Johnson Creek	1	0.8	3.5	8.0	18.4	0.0
	2	0.5	7.9	15.4	13.9	0.0
Klootchy Creek	1	2.5	2.6	8.2	18.8	0.0
	2	1.3	5.8	13.4	39.4	0.0
Lindsley Creek	1	0.6	6.8	8.3	8.2	0.0
Little Humbug Creek	1	0.9	2.6	12.9	26.5	0.0
	2	0.8	5.5	6.8	19.8	0.0
Little Joe Creek	1	1.5	6.4	12.5	14.2	0.0
Mail Creek	1	1.0	3.3	6.6	12.2	0.0
South Fork Necanicum R., Trib a	1	0.8	6.0	11.4	10.0	0.0
	2	1.1	4.2	11.7	9.5	0.0
	3	0.6	5.8	21.8	23.3	0.0
South Fork Necanicum River	1	1.3	2.0	3.8	6.7	0.0
	2	0.9	2.9	6.0	5.7	0.0
Upper Necanicum River	1	1.7	1.4	6.9	5.8	0.0
	2	0.9	1.5	3.4	1.3	0.0
	3	0.8	2.5	5.5	3.2	0.0
	4	1.9	3.3	11.0	22.7	0.0
Volmer Creek	1	0.9	2.6	4.0	4.9	0.0
	2	0.9	4.5	3.5	4.8	0.0
Warner Creek	1	1.0	2.9	5.6	4.9	0.0
Williamson Creek	1	0.7	1.6	6.5	9.5	0.0
	2	0.6	2.6	13.1	15.4	0.0

Legend: light grey = Desirable; dark grey = Undesirable; white = Moderate

Table 3.4. Riparian conifer conditions in the Necanicum River watershed as compared to ODFW habitat benchmark values. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW.

Stream	Reach	Stream Miles	Gradient (%)	Width (m)	Shade (%)	# Conifers > 20" dbh per 100 ft stream length	# Conifers > 35" in dbh per 1,000 ft stream length
Beerman Creek	1	1.8	1.5	3.6	75.0	0.0	0.0
	2	0.9	2.7	3.1	88.0	0.0	0.0
Bergsvik Creek	1	1.5	1.1	4.4	70.0	0.0	0.0
	2	1.2	1.8	2.7	72.0	0.0	0.0
Brandis Creek	1	0.5	4.8	2.1	89.0	0.0	0.0
Circle Creek	1	2.9	0.4	5.3	69.0	0.0	0.0
	2	1.1	2.0	3.6	75.0	0.0	0.0
	3	0.7	2.5	2.2	78.0	0.0	0.0
Grindy Creek	1	1.0	3.0	2.9	85.0	0.0	0.0
Johnson Creek	1	0.8	3.5	2.6	85.0	0.0	0.0
	2	0.5	7.9	2.1	88.0	0.0	0.0
Klootchy Creek	1	2.5	2.6	4.0	82.0	0.0	0.0
	2	1.3	5.8	3.0	87.0	0.0	0.0
Lindsley Creek	1	0.6	6.8	2.5	74.0	0.0	0.0
Little Humbug Creek	1	0.9	2.6	3.3	72.0	0.0	0.0
	2	0.8	5.5	3.7	82.0	0.0	0.0
Little Joe Creek	1	1.5	6.4	2.5	82.0	0.0	0.0
Mail Creek	1	1.0	3.3	3.9	85.0	0.0	0.0
South Fork Necanicum R., Trib a	1	0.8	6.0	4.6	76.0	0.0	0.0
	2	1.1	4.2	4.2	81.0	0.0	0.0
	3	0.6	5.8	3.3	88.0	0.0	0.0
South Fork Necanicum River	1	1.3	2.0	4.8	96.0	0.0	0.0
	2	0.9	2.9	4.8	68.0	0.0	0.0
Upper Necanicum River	1	1.7	1.4	6.4	59.0	0.0	0.0
	2	0.9	1.5	6.3	61.0	0.0	0.0
	3	0.8	2.5	4.6	72.0	0.0	0.0
	4	1.9	3.3	2.9	67.0	0.0	0.0
Volmer Creek	1	0.9	2.6	3.1	84.0	0.0	0.0
	2	0.9	4.5	1.7	88.0	0.0	0.0
Warner Creek	1	1.0	2.9	2.8	89.0	0.0	0.0
Williamson Creek	1	0.7	1.6	2.4	71.0	0.0	0.0
	2	0.6	2.6	3.2	85.0	0.0	0.0

(light grey) = Desirable; (dark grey) = Undesirable; (white) = Moderate

stream channel. Natural and human degradation of riparian zones diminish their ability to provide these critical ecosystem functions.

Riparian vegetation frequently occurs in several zones parallel to the stream bank. For example, often a band of young hardwoods lines the stream bank, behind which is a zone of conifers. Consequently, riparian vegetation was assessed for two zones parallel to the stream bank (RA1 and RA2), for the left and right side of the stream separately (Table 3.5).

Table 3.5. Large woody debris recruitment potential from two parallel riparian zones (RA1 and RA2). RA1 extends from 0 to x feet and RA2 from x to 100 feet from the streambank, where the distance x is given in Table 3.6.

Subwatershed	Stream Length (mi)	RA1 (%)			RA2 (%)			Overall Average (%)		
		Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Beerman / Tillamook	24	78	22	0	80	20	0	79	21	0
Klootchy / Mail Creek	27	89	11	0	89	11	0	89	11	0
Neacoxie	7	10	90	0	10	90	0	10	90	0
North Fork / Humbug	31	91	9	0	93	7	0	92	8	0
Seaside	19	97	3	0	95	5	0	96	4	0
South Fork	27	92	8	0	90	10	0	91	9	0
Upper Necanicum	27	76	24	0	73	27	0	75	25	0
Average for Necanicum Watershed	162	83	17	0	83	17	0	83	17	0

* Percentages do not necessarily add up to 100% due to non-forested areas.

Specific information regarding the health and integrity of the riparian zones within the Necanicum River watershed is generally not available. For this assessment, we evaluated the ability of the riparian zones to provide LWD to the stream system and the extent of riparian shading provided to the stream.

Although LWD may theoretically reach the stream from a distance of a site potential tree height, the majority of functional wood has been found to come from within 100 feet of the stream. The overall width of these two zones was therefore set at 100 feet, although the RA1 width was based on ecoregion and side slope constraint, according to OWEB recommendations (McDade et al 1990, WPN 1999). RA1 widths are shown in Table 3.6. Riparian vegetation categorization was conducted by examining digital orthophotos taken in 1994. The stream channel data layer was overlayed on the orthophotos in the GIS, and buffers were drawn on each side of the streams, corresponding to the appropriate RA1 and RA2 buffer distances.

Table 3.6 RA1 widths based on channel constrainment and ecoregion (WPN 1999).			
	RA1 Width (ft)		
Constraint	Coastal Lowlands	Coastal Uplands	Willapa Hills
Unconstrained	25	75	75
Moderately Constrained	25	50	50
Constrained	25	25	25

3.3.1 Large Woody Debris Recruitment Potential

Riparian vegetation was categorized as having a high, moderate, or low potential for large woody debris recruitment. Vegetation classes defined as coniferous or mixed in the large class (>24 inch dbh) had a high potential for LWD recruitment. Coniferous or mixed vegetation in the medium size class (12-24 inch dbh), and hardwoods in the medium to large class, had moderate potential for LWD recruitment (Table 3.7).

Recruitment potential of LWD from the riparian zone was identified based on the size and species of trees in the riparian zone and their distance from the streambank, according to the OWEB methodology. It provides a coarse-screening of the overall condition of LWD recruitment potential throughout the watershed. However, it should be noted that not all areas would contribute large amounts of LWD to the stream system even if there was a high density of

Table 3.7. Descriptions of large woody debris recruitment potential classes. Vegetation is categorized by average stand density, tree size (dbh), and species composition (coniferous, hardwood, and mixed).		
Recruitment Potential	Stand Density*	Description
Low	Dense	Small trees of all species (<12" dbh)
	Sparse	Small trees of all species (<12" dbh), and sparse medium-sized hardwoods (12" - 24" dbh)
Moderate	Dense	Medium-sized conifers, hardwoods, and mixed conifers/hardwoods (12" - 24" dbh)
	Sparse	Large conifers and mixed large conifers/hardwoods (>24" dbh); Medium-sized conifers, mixed medium conifers/hardwoods (12" - 24")
High	Dense	Large conifers and mixed large conifers/hardwoods (>24" dbh**)
*Dense: <1/3 of ground exposed; sparse: > 1/3 of ground exposed **Diameter breast-height		

large conifers. In general, large streams (i.e. >5th-order) low in the watershed are not likely to contribute as much LWD as smaller streams in the middle portion of the watershed. This is because large streams often are in flat valley bottoms with wide gravel bars along the banks, whereas in the upper part of the watershed hillslopes are usually steeper, channels straighter, and banks narrower. The lower river collects wood transported from upstream and provides LWD to the estuary, where it contributes to estuarine habitat improvement.

The potential for LWD recruitment in the Necanicum River watershed was poor (Figure 3.2). None of the riparian areas in the watershed demonstrated a high potential to contribute LWD to the stream channel. The average LWD recruitment potential of surveyed streams indicated that 83 percent were low, 17 percent were moderate, and none were high. In all except one (Neacoxie Creek), the majority of LWD recruitment potential was low (Table 3.5). The lack of large conifers (>24" dbh) in this watershed is likely a result of historic vegetation removal and fires along the riparian corridor.

3.3.2 Stream Shading

Riparian vegetation provides shade and insulation that helps moderate stream temperatures. While shade will not actually cool a stream, riparian vegetation blocks solar radiation before it reaches the stream and prevents the stream from heating (Bischoff et al. 2000, Beschta 1997, Boyd and Sturdevant 1997, Beschta et al. 1987). The shading ability of the riparian zone is determined by the quality and quantity of vegetation present. In general, the wider the riparian zone and the taller and more dense the vegetation, the better the shading ability (Beschta 1997, Boyd and Sturdevant 1997). Current shade conditions for the Necanicum River watershed were estimated from the aerial photo interpretation.

Results from our air-photo analysis of stream shading yielded similar results to the stream reach surveys of ODFW. Stream shading conditions were generally high across much of the watershed, except along Neacoxie Creek and the mainstem Necanicum River, where stream shading was low in most places (Table 3.4, Figure 3.3). Stream shading conditions were best (96 percent classified as high) in the South Fork Necanicum River subwatershed and worst (0 percent high; 0 percent medium) in the Neacoxie Creek subwatershed (Table 3.8).

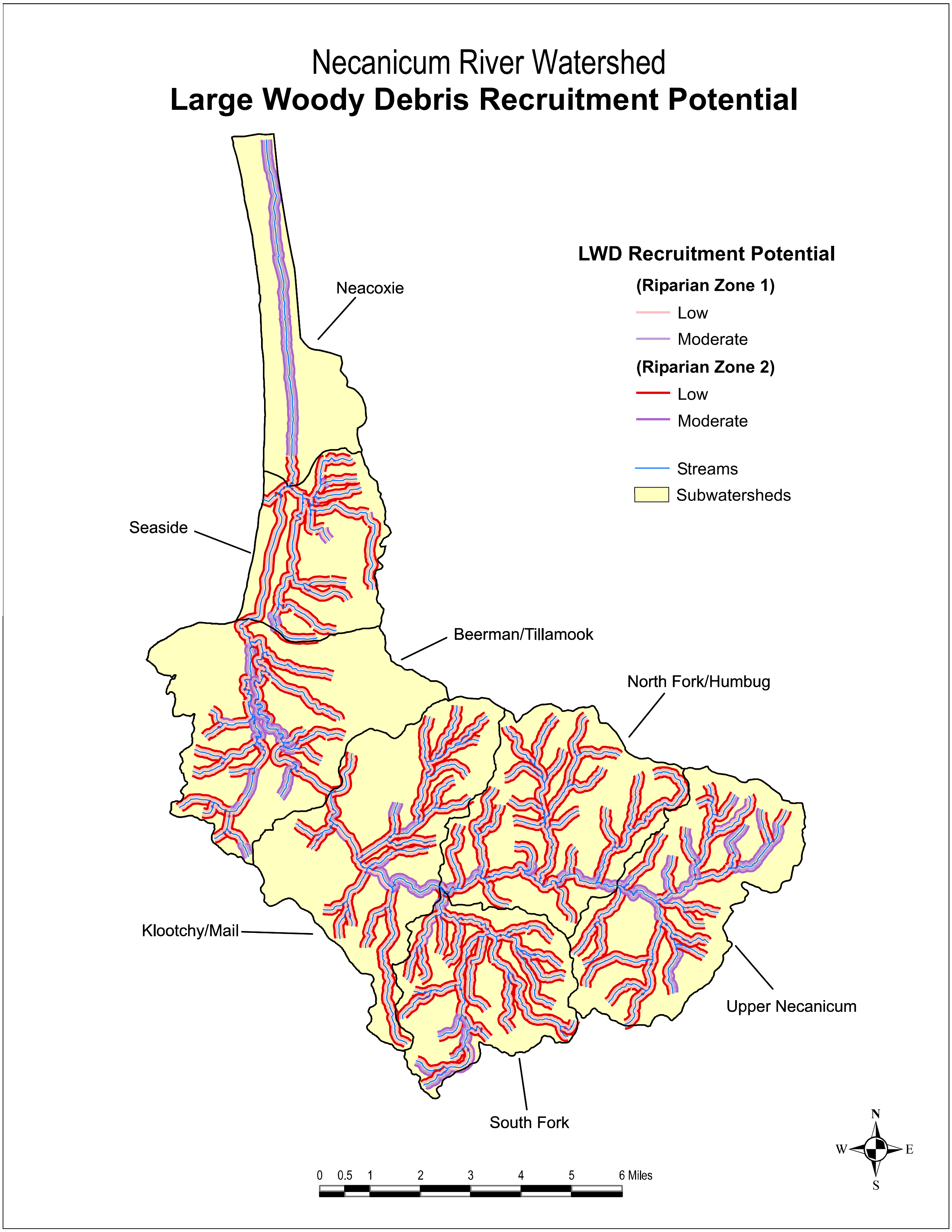


Figure 3.2. Large woody debris recruitment potential.

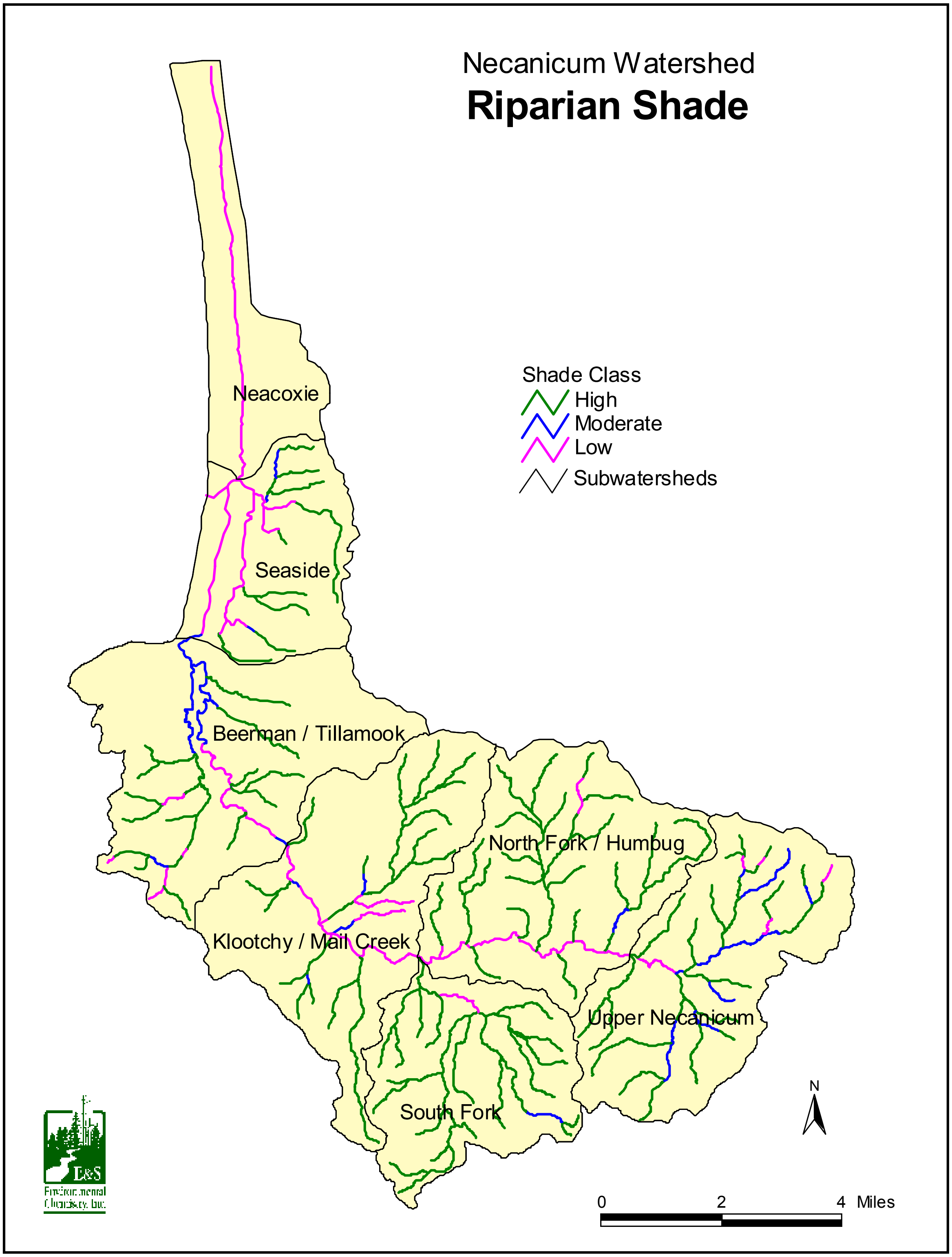


Figure 3.3. Riparian shade conditions in the Necanicum River watershed. Data were developed from aerial photo interpretation conducted by E&S Environmental Chemistry, Inc. Because the photos were taken in 1994, actual current conditions may differ somewhat from those reported here.

Table 3.8. Current stream shading conditions in the Necanicum River watershed, based on aerial photo interpretation conducted by E&S.

Subwatershed	Total Stream (mi)	% High	% Medium	% Low	Estuarine Wetlands (%)	Palustrine Wetlands (%)
Beerman / Tillamook	25	52	16	15	0	17
Klootchy / Mail Creek	27	70	5.5	17	0	7
Neacoxie	7	0.0	0.0	46	3	52
North Fork / Humbug	31	78	4.7	12	0	6
Seaside	19	42	0.9	17	9	31
South Fork	27	96	1.6	2.6	0.0	0.0
Upper Necanicum	27	71	17	5.1	0.0	7.0
Total	163	58	6.5	16	2	17

3.4 Fish Passage Barriers

Stream channels are often blocked by natural barriers, such as waterfalls, or by human-caused barriers, especially poorly designed culverts at road crossings. This has resulted in significant loss of fish access to suitable habitat. Anadromous fish migrate upstream and downstream in search of food, habitat, shelter, spawning beds, and better water quality. Fish populations can be significantly limited if they lose access to key habitat areas. As many as 75 percent of culverts in some forested drainages are either impediments or outright blockages to fish passage, based on surveys completed in Washington state (Conroy 1997). Surveys of county and state roads in Oregon have found hundreds of culverts that at least partially block fish passage. Potential effects from the loss of fish passage include loss of genetic diversity by isolation of reaches, loss of range for juvenile anadromous and resident fish, and loss of resident fish from extreme flood or drought events (prevents return).

Known fish passage barriers in the Necanicum River watershed are shown in Figure 3.4. Natural barriers tend to be located in upper tributary sections of the watershed.

3.4.1 Natural Barriers

Several natural fish passage barriers in the Necanicum River watershed were identified by ODFW (*http://rainbow.dfw.state.or.us*). None block access to extensive anadromous fish habitat.

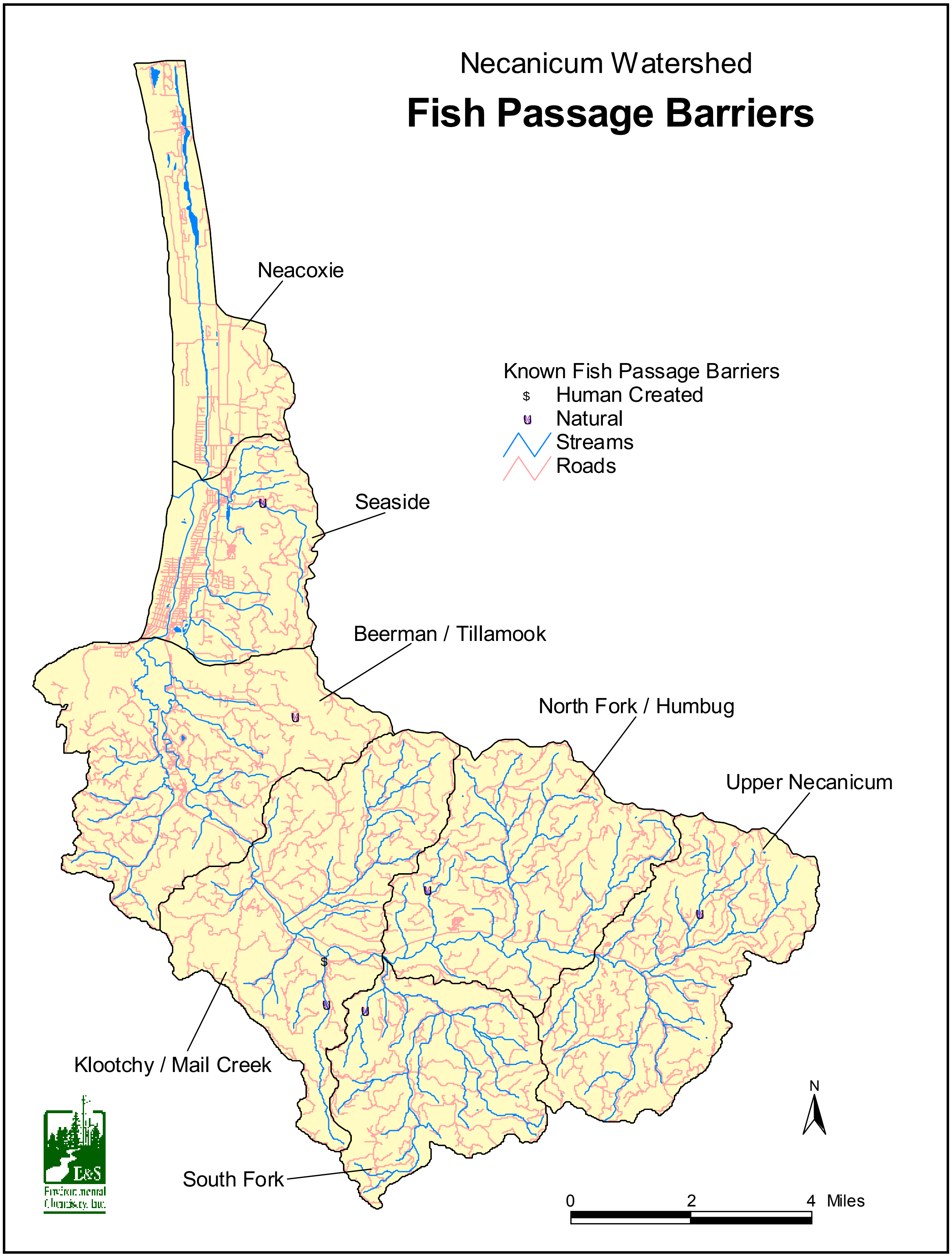


Figure 3.4. Location of roads and streams and known fish passage barriers (excluding impassable culverts) in the Necanicum River watershed.

3.4.2 Culverts

Culverts can pose several types of problems for fish passage, including excessive height above the downstream pool, excessive water velocity, insufficient water depth in culvert, disorienting flow patterns, and lack of resting pools between culverts. Culverts can also limit fish species only during certain parts of their life cycles. For example, a culvert may be passable to larger adult anadromous fish and not passable to juveniles. Culverts may also act as passage barriers only during particular environmental conditions, such as high flow or low flow events. Because of the variety of potential effects, it is important to understand the interactions of habitat conditions and life stage for anadromous fish.

The Necanicum River watershed has an average stream crossing density of 3.2 stream crossings per square mile. Stream crossing densities were highest in the South Fork and Seaside subwatersheds (4.4 and 4.2 crossings/mi^2, respectively). Only 23 culverts out of a total 269 road-stream crossings have been surveyed by ODFW for potential fish passage barriers and 69 percent of those surveyed were judged to be impassable (ODFW 1997b; Figure 3.5, Table 3.9). The Upper Necanicum subwatershed contained half of the surveyed culverts in the watershed that were judged to be impassable. All surveyed culverts in that subwatershed were rated impassable. It should be noted that only a very small percentage of the culverts in the watershed have been surveyed to evaluate fish passage and were available for analysis for this report. Available culvert data are from 1997, and should generally be reflective of curent problem

Table 3.9. Culverts and road/stream crossings in the Necanicum River watershed. Road/stream crossings were generated using GIS. Culvert data were provided by ODFW.

Subwatershed	Area (sq. mi.)	Surveyed Culverts		Road-Stream Crossings	
		# Surveyed	# Impassable	#	#/mi^2
Beerman / Tillamook	15.7	7	4	60	3.8
Klootchy / Mail Creek	15.3	1	1	40	2.6
Neacoxie	7.3	0	0	6	0.8
North Fork / Humbug	13.7	3	1	45	3.3
Seaside	8.3	4	2	35	4.2
South Fork	9.9	0	0	43	4.4
Upper Necanicum	13.3	8	8	40	3.0
TOTAL	83.5	23	16	269	3.2

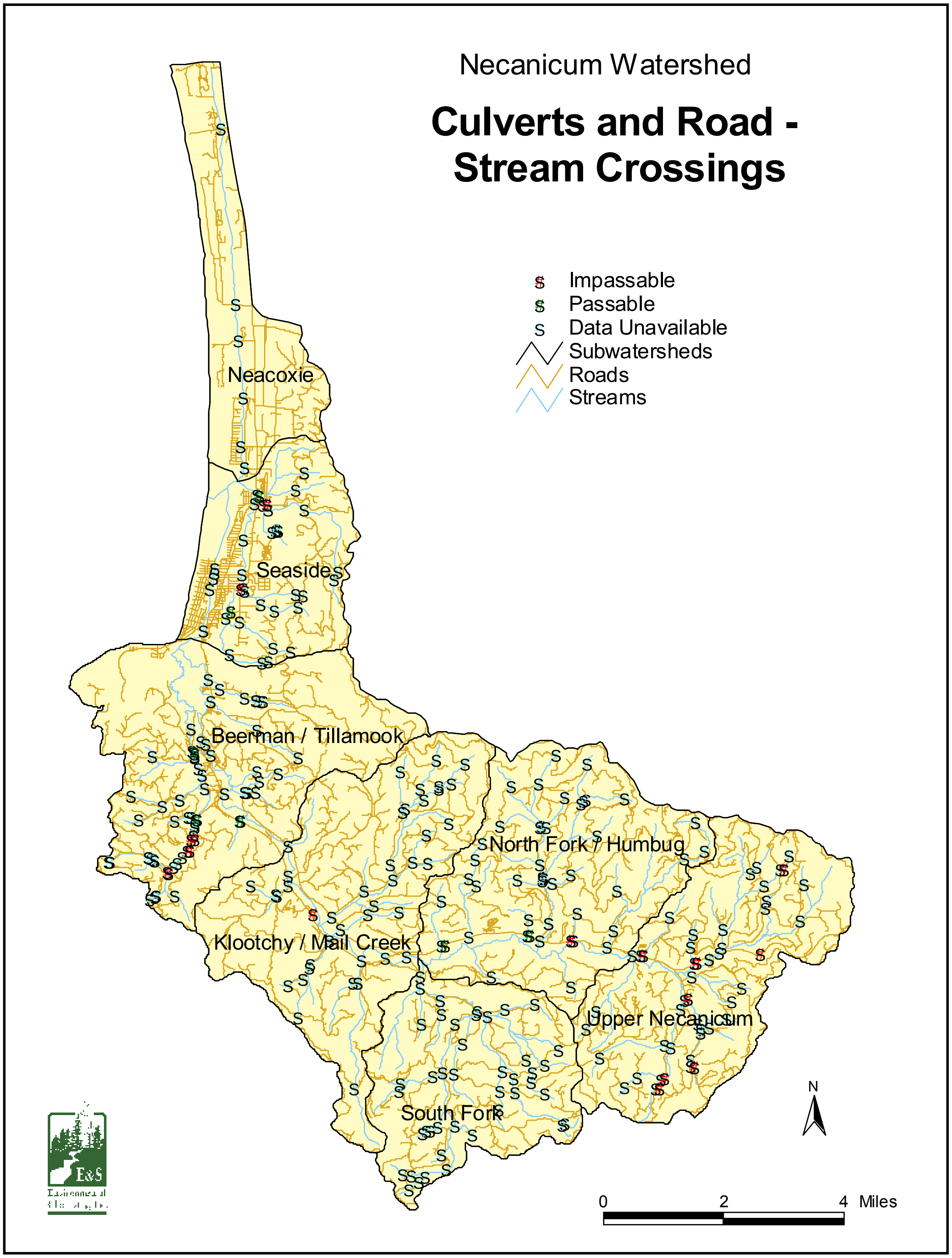


Figure 3.5. Location of culverts (road/stream crossings) in the Necanicum River watershed, coded to show which have been surveyed by ODFW for fish passage and the results of those surveys (passable or impassable). Additional data exist for culverts on Willamette Industries land, but these data were not available to be analyzed for this report. (Source: ODFW 1997b)

culvert locations. The data do not indicate the nature of the problem at each culvert or the extent to which it constitutes a fish barrier. Additional culvert data have been collected by Willamette Industries but were not analyzed and included in this assessment. Longview Fibre has assessed culverts on their property, and identified 1 salmonid passage barrier, for which they have secured a grant to do repair work, and 12 culverts that may be barriers to resident cutthroat passage.

3.5 Channel Modifications

In-channel structures and activities such as dams, dredging or filling can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream channel. These changes can ultimately alter community composition of instream aquatic biota. Identification of channel modification activities can help in the determination of the likely effects of anthropogenic channel disturbances on channel morphology, aquatic habitat, and hydrologic functioning.

The present condition of freshwater habitat in the Necanicum River Watershed has been heavily influenced by human activities and natural phenomena that have occurred over an extended period of time.

Disconnecting the floodplain from the river can lead to reduced physical complexity and channel downcutting due to increased water velocities, resulting in deteriorated habitat conditions. Additionally, disconnection from the floodplain can lead to changes in the biotic structure of the aquatic ecosystem by limiting nutrient and organic material exchanges between the stream and floodplain.

One primary natural function of a floodplain is to store flood waters during high flow events. Natural floodplains tend to lower flood water elevations downstream and reduce downstream flood hazards and property damage. As an example of this natural flood reduction benefit, an approximate 8-mile length of the floodplain along the Skykomish River in Washington State stores enough flood water to reduce flood flows by about 5 percent at downstream valley locations (Snohomish County Public Works 1996). In the Necanicum River lowlands, some floodplain storage has been lost due to the construction of dikes and urban development along the estuary. Flood control efforts have also blocked some of the natural ability of the river floodplains to spread out flood waters, and thus the ability to slow and store flood waters flowing from the upland portions of the watersheds.

These attempts to control flooding have reduced the natural complexity of the river channel and have separated the river from the floodplain. The loss of natural floodplain functions due to diking has often impacted other resources with economic value, such as the fish and shellfish industries, which attracted commercial and residential development to the floodplain (Coulton et al. 1996). To some degree the diking has increased streambank erosion by increasing water depth and flow velocity between the dikes (Leopold et al. 1992). In addition, the removal of large woody debris has made streambanks more vulnerable to this type of erosion process.

The concept of working with the river's own natural functions to manage floods is replacing the concept of intervening in these processes to try to control floods (TBNEP 1998). Interest is growing in non-structural floodplain management methods, such as enforcing land use ordinances and restoring the floodplains.

Unaltered streams in natural lowland valley bottoms often meander through rich forested wetlands. These naturally meandering channels and adjacent wetlands typically have more frequent flooding, but lower flood peaks than human-altered streams and floodplains in similar geomorphic settings (Shields and Cooper 1994). Flood waves traveling through valley streams with natural riparian wetland floodplains have been observed to rise more gradually, reach lower peak elevations, and last longer than floods occurring on altered floodplains, which produced sharper, higher, and flashy flood conditions (Shields and Cooper 1994). Natural riparian wetlands help to distribute flood flows and store water for slower release.

It is likely that the historic floodplain landscape of the Necanicum watershed was much different than today. Historic valley landscapes were heavily forested bottom lands and wetlands which flooded often. These vegetative characteristics have been replaced in the lower river by constrained river banks and urban development. These changes have altered the ability of the floodplain to store and mitigate flood waters, as well as to provide off-channel habitat.

3.6 Wetlands

Wetlands contribute critical functions to watershed health, including water quality improvement, filtration, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Because of the importance of these functions, wetlands are regulated by both state and federal agencies. Determining the location and extent of wetlands within a watershed is critical to understanding watershed structure and function.

At 450 acres, the Necanicum River Estuary is Oregon's 15th largest estuary. Nearly one-third of the estuary is occupied by tidal wetland (Table 3.10). Most estuaries in Oregon have been significantly changed, mainly through the diking and draining of estuarine marshes in the early to mid-1900s for agricultural development. Filling of intertidal land for urban and road development continued through the late 1960s. Good (2000) summarized such changes for Oregon's 17 largest estuaries, including the Necanicum. The loss of tidal wetlands was actually rather modest in the Necanicum River Estuary (-10 percent, Table 3.10) compared with the other estuaries in Oregon, which averaged a loss of 68 percent of tidal wetlands. In fact, of the 17 estuaries evaluated, only two (Netarts and Sand Lake) showed less tidal wetland loss and all except Netarts, Sand Lake, and Rogue River Estuaries were estimated to have lost more than half of their original tidal wetland area (Good 2000).

Table 3.10. Changes in total area and area of tidal wetlands in the Necanicum River Estuary due to diking and filling that occurred from about 1870 to 1970. (Source: Good 2000)

	Actual or Estimated Area (ac)		Percent Change
	1970	1870	
Tidal wetland	132	147	-10%
Total estuary	451	466	-3%
Diked or filled tidal wetland	15	0	

3.6.1 National Wetlands Inventory

The primary source for wetland information used in this assessment was National Wetlands Inventory (NWI) maps created by the U.S. Fish and Wildlife Service. Very few of the NWI quads were digitized for the Necanicum River watershed, so information was generally derived from hard copy NWI maps. NWI maps were created from interpretation of 1:58,000-scale aerial photos that were taken between October, 1981 and the present. It is important to note that NWI wetland maps are based on aerial photo interpretation and not on ground based inventories of wetlands. On-the-ground inventories of wetlands often identify extensive wetlands that are not on the NWI maps.

3.6.2 Wetland Extent and Types

Because digital NWI data were not available, wetland extent was calculated from the refined land use coverage generated as a part of this study. Wetlands were identified from a 1992 LANDSAT image obtained from CREST and C-CAP. The image was classified and field verified by C-CAP using local wetland inventories and NWI data.

Wetlands are an important landscape feature in the Necanicum River watershed (Table 3.11, Figure 3.6). The predominant wetland type is palustrine wetlands with some estuarine wetlands and mixed agricultural wetlands in the lower elevations. Palustrine wetlands are defined as all non-tidal wetlands dominated by trees, shrubs, and persistent emergents and all wetlands that occur in tidal areas with a salinity below 0.5 parts per thousand (Mitsch and Gosselink 1993, Cowardin et al. 1979). Palustrine wetlands are common along many of the stream corridors and are heavily distributed throughout the Neacoxie Creek subwatershed. Estuarine wetlands are defined as deepwater tidal habitats and adjacent tidal wetlands that are usually semiclosed by land but have open, partially obstructed, or sporadic access to the ocean and in which ocean saltwater is at least occasionally mixed with freshwater (Mitsch and Gosselink 1993, Cowardin et al. 1979). Prior to the 1970's, many estuarine wetlands were lost as a result of dikes and levees that removed the saltwater influence. Estuarine wetlands have since been protected, and losses minimized. However, many of the existing salt marshes have been recreated over the past 50 years and probably lack the diversity of habitats that the older salt marshes provided prior to disturbance (Coulton et al. 1996).

Table 3.11. Wetland area in the Necanicum River watershed calculated from the refined land use cover described in Chapter 1.

Subwatershed	Subwatershed Area (mi^2)	Estuarine Wetland (%)	Palustrine Wetland (%)
Beerman / Tillamook	15.8	0.25	4.43
Klootchy / Mail Creek	15.3	-	1.69
Neacoxie	7.4	0.20	37.24
North Fork / Humbug	13.7	-	3.51
Seaside	8.3	3.22	14.46
South Fork	9.9	-	-
Upper Necanicum	13.3	-	3.01
Total	83.7	0.39	6.91

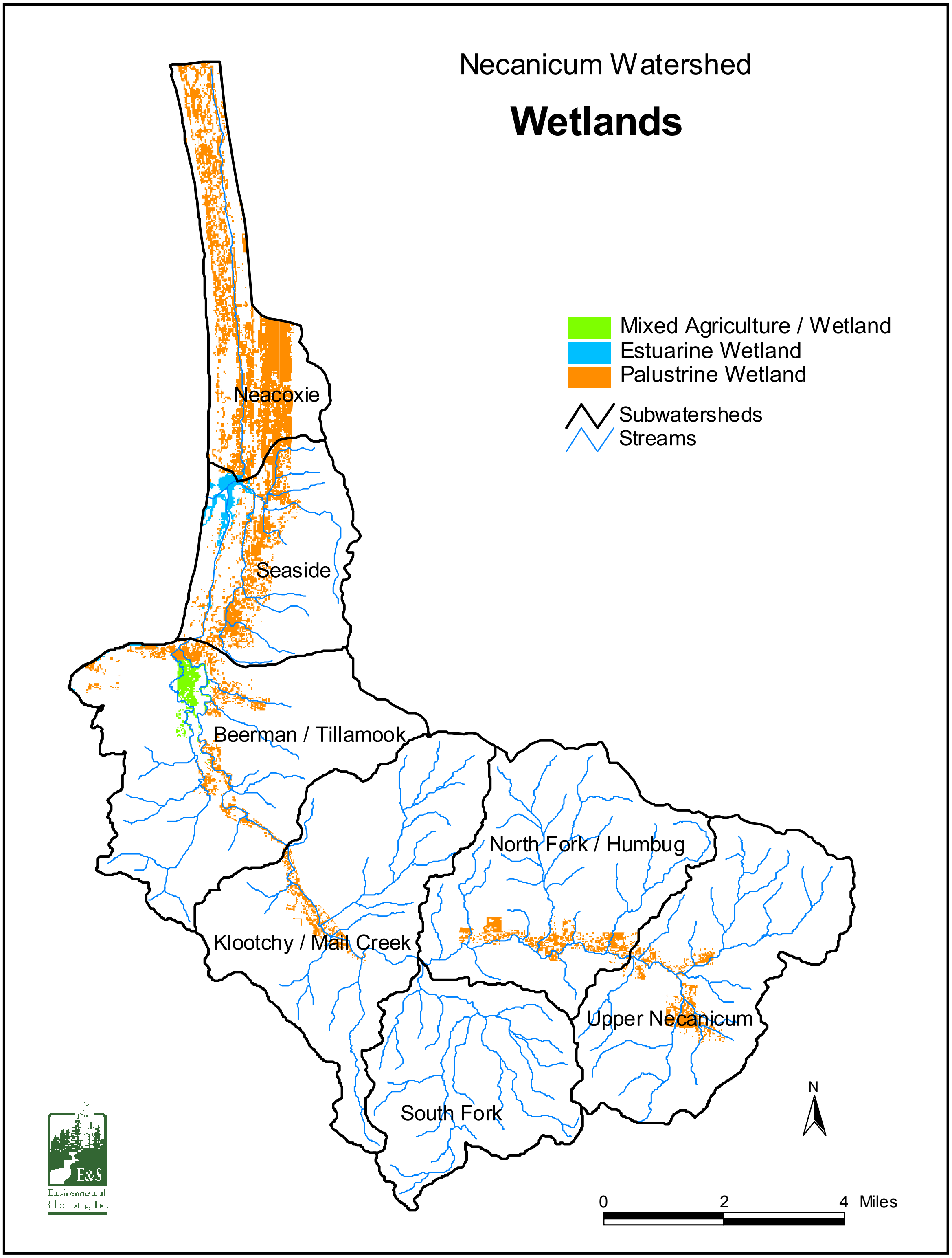


Figure 3.6. Location of wetlands in the Necanicum river watershed.

Palustrine wetlands occupy 6.9 percent of the watershed. They are most prevalent in the Neacoxie (37 percent) and Seaside (14.5 percent) subwatersheds (Table 3.11).

The Cowardin classification system is used by the NWI and others in classifying wetlands. It is based on wetland type, vegetation or substrate type, and hydrology. The classification system is a hierarchical approach, whereby the wetland is assigned to a system, subsystem, class, subclass, and water regime. Common types and characteristics of wetlands in the Necanicum River watershed are shown in Table 3.12.

3.6.3 Wetlands and Salmonids

Wetlands play an important role in the life cycles of salmonids (Lebovitz 1992, Shreffler et al. 1992, MacDonald et al. 1988, Healey 1982, Simenstad et al. 1982). Estuarine wetlands provide holding and feeding areas for salmon smolts migrating out to the ocean. These estuarine wetlands also provide an acclimation area for smolts while they are adapting to marine environments. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate (Mitsch and Gosselink 1993).

Table 3.12. Common NWI wetland types located in the Necanicum watershed. Wetland codes are from the Cowardin Wetland Classification used by NWI (Cowardin et al. 1979).

Code	System	Class	Water Regime
PSSC	P= palustrine	SS=Scrub/Shrub	C = Seasonally flooded
PEMF	P= palustrine	EM=emergent	F= Semipermanently flooded
PEMC	P= palustrine	EM=emergent	C = Seasonally flooded
PEMCh	P= palustrine	EM=emergent	C = Seasonally flooded h=Diked/impounded
PEMFb	P= palustrine	EM=emergent	F= Semipermanently flooded b= beaver
PFOA	P= palustrine	FO=Forested	A=Temporarily Flooded
PSSR	P= palustrine	SS=Scrub/Shrub	R=Seasonal/Tidal
PEMT	P= palustrine	EM=emergent	T=Semipermanent -tidal
PEMR	P= palustrine	EM=emergent	R=Seasonal/Tidal
PEMA	P= palustrine	EM=emergent	A=Temporarily Flooded
PUBH	P= palustrine	UB=Unconsolidated Bottom	H=Permanently Flooded
PUBHh	P= palustrine	UB=Unconsolidated Bottom	H=Permanently Flooded h=Diked/impounded
PSSY	P= palustrine	SS=Scrub/Shrub	Y=Saturated/Semipermanent/ Seasonal
PFOW	P= palustrine	FO=Forested	W=Intermittently Flooded

Wetlands also provide cover and a food source in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream.

Wetlands that intersect streams (Table 3.13) represent important salmonid habitats (WPN 1999, Lebovitz 1992). ODFW habitat surveys identified a general lack of off-channel refuge habitat such as alcoves, side channels, and connected wetland areas. These areas are particularly important in the over-winter survival of coho salmon and sea-run cutthroat trout and steelhead trout. Off-channel sites provide refuge from high sediment loads and high water velocities which occur in most larger stream channels during frequent winter rain events. Lack of off-channel refuge areas can be partially compensated for if in-channel refuge habitat (*e.g.*, root wads, debris jams, deep pools with complex cover) is abundant. However, as discussed previously, LWD is usually necessary for creation of such habitat in Coast Range streams.

Thirty seven percent of the stream length in the Neacoxie Creek subwatershed intersects palustrine wetlands. In addition, 14.4 percent of the stream length in the Seaside subwatershed intersects palustrine wetlands and 3.2 percent intersects estuarine wetlands. In the Beerman/Tillamook subwatershed, 1.8 percent of the stream length intersects agricultural wetland areas (Table 3.13).

Table 3.13. Percent stream channel lengths that intersect wetlands.

	Total Stream Miles	Agricultural Wetlands (%)	Estuarine Wetlands (%)	Palustrine Wetlands (%)
Beerman / Tillamook	25	1.8	0.2	4.4
Klootchy / Mail Creek	27	0	0	1.7
Neacoxie	7	0	0.2	37.2
North Fork / Humbug	31	0	0.0	3.5
Seaside	19	0	3.2	14.4
South Fork	27	0	0	0
Upper Necanicum	27	0	0	3.0
Total	163	0.3	0.4	6.9

According to the TBNEP environmental characterization report (TBNEP 1998), available information suggests that ample organic matter is available to supply animal populations in Northwest estuaries (Simenstad *et al.* 1984, Wissmar and Simenstad 1984, Wissmar 1986).

However, in situations where populations are very abundant, local food resources may be limiting. It has been proposed that limited estuarine food resources may be partly responsible for declines in some natural salmon runs over the last century, as well as the lack of success of some hatchery stocks. When many juveniles reach the estuary at once (such as during a heavy natural outmigration or following release from a hatchery), they may dramatically reduce the size of the local invertebrate populations. Prey resources are further limited, and recovery of the prey population is protracted, in areas where shallow flats, marshes and quiet channel habitat have been removed by dredging and channelization. Simenstad *et al.* (1982) hypothesized that in this situation the salmon may spend less time in the estuary. As smaller outmigrants to the ocean, they would then be more susceptible to open water predators. It is not known if this is a problem in the Necanicum River Estuary now, but it should be considered for future salmonid management (c.f., TBNEP 1998).

Table 3.14 summarizes the habitat types and juvenile residency information for the five salmonid species found in the Necanicum River watershed. Of the five species, chinook salmon and chum salmon depend most on the estuary, followed by cutthroat trout. Most coho salmon and steelhead trout appear to use estuaries primarily as a migratory route and as a physiological transition zone for ocean residency.

Table 3.14. Primary estuarine habitats utilized by juvenile anadromous salmonids and approximate period of residency of individual fish (Healey 1982, Simenstad and Salo 1982, Iwamoto and Salo 1977).

SPECIES	PRIMARY HABITAT UTILIZED					RESIDENCY (approximate range for individual fish)
	Salt marsh	Eelgrass	Mud flat	Tidal channel	Open water	
Chinook	X	X	X	X	X	weeks to months
Chum	X	X		X		days to about 1 month
Coho			X(?)	X	X	days to months
Steelhead			X(?)	X	X	days to a few weeks
Sea-run cutthroat		X	X(?)	X	X	weeks to months

3.6.4 Filling and Diking of Wetlands

Wetlands have been one of the landscape features most impacted by human disturbance. In the Pacific Northwest, it is estimated that 75 percent of the original wetlands have been lost to human disturbances (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1990). Somewhere between 50 and 90 percent of tidal marshes in most individual Oregon estuaries have been lost, most as a result of agricultural activities (Frenkel and Morlan 1991, Boule and Bierly 1987). Loss of wetlands that were connected to the stream system can lead to salmonid habitat loss and loss of flood attenuation.

Natural tidal marshes are sediment sinks. Dikes and levees constructed on tidal marsh lands have reduced the natural ability of estuary marshes to remove sediments by increasing the concentration of suspended riverine sediments transported directly into the bay. Sediments deposited in non-vegetated sloughs and mud flats are more likely to be resuspended by wind and wave action and transported into deeper navigable portions of the estuary than if they were deposited in vegetated tidal marshes. For estuaries experiencing a rising sea-level, restored tidal marshes can serve as long-term sediment sinks, keeping pace with the changing sea-level.

Extensive urban development has occurred in the Necanicum River floodplain, and it may continue in association with increased population growth. Continued development has the potential to further impact wetlands within the watershed. Wetlands are regulated so that any filling of wetlands must be mitigated by either wetland construction or restoration. However, it is unclear as to whether the mitigation wetland can replace the lost functions of a filled natural wetland.

3.7 Conclusions

Aquatic and riparian habitats have been substantially altered throughout the Necanicum River watershed. Both habitat condition and access to habitat by biota, including anadromous fish, have been adversely impacted. Large woody debris (LWD) is generally lacking throughout the watershed. Although stream shading is rated as desirable in most subwatersheds, potential future recruitment of LWD is poor, largely because large conifers have been replaced by smaller-diameter deciduous trees in many riparian areas.

Fish passage barriers appear to be numerous; 69 percent of surveyed culverts were judged to constitute impediments to fish passage, although, to date, few culverts have been surveyed by ODFW, and Willamette Industries and Longview Fibre culvert data have not been analyzed for

this assessment (Table 3.9). Impassable culverts seriously limit the utilization of otherwise-suitable fish habitat. Channelization, diking, and dredging of lowland areas have simplified habitat structure in the lowlands, altered access to aquatic biota, and changed sedimentation and flooding regimes. All of these changes have adversely impacted habitat quality. Both the tidal-influenced wetland and intertidal mudflat habitat types have been reduced since the mid-1800s. The filling and diking of wetlands have removed, or cut off access to, important off-channel refugia and overwintering areas for salmonid fish.

Thus, the overall condition of aquatic and riparian habitats in the watershed has been dramatically changed. Habitat quality for salmonid fish and other biota has been reduced. On-going and future efforts to restore habitat quality include, in particular, replacement of culverts that have blocked fish access to important habitat, improvement of in-stream LWD conditions and LWD recruitment potential, and reconnection and restoration of wetlands.

CHAPTER 4. HYDROLOGY

4.1 Introduction

Human activities in the watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and the condition of aquatic habitats. Changes in the landscape can increase or decrease the volume, size, and timing of discharge and affect low flows by changing groundwater recharge. Some examples of human activities that can affect watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. The focus of the hydrologic analysis component of this assessment is to evaluate the potential impacts from land and water use on the hydrology of the watershed (WPN 1999). It is important to note, however, that this assessment only provides a screening for potential hydrologic impacts based on current land use activities in the watershed. Identifying those activities that are actually affecting the hydrology of the watershed and quantifying the magnitude of those effects would require a more in-depth analysis and is beyond the scope of this assessment.

Freshwater inflows are vitally important for the maintenance of plant and animal communities in both the river and the estuary. Despite the importance of this issue, however, available data are limited regarding the extent to which flows have changed in coastal basins over the past 150 years and what impacts those changes may have caused (Good 2000). Studies are needed on the effects of upstream water withdrawals on the habitats and water quality of all of Oregon's estuaries, including the Necanicum.

Topography in the Necanicum River watershed is characterized by steep headwaters that lead quickly into low gradient floodplains. Elevations in the watershed range from sea-level to 2,846 feet it its highest point. Precipitation ranges from 74 inches annually in the lowlands to about 150 inches in the highest elevations of the watershed. The Oregon Coast Range, including the Necanicum River watershed, is characterized by a strong orographic effect on precipitation as demonstrated by the large differences between lowland and upland precipitation totals (Table 4.1).

Table 4.1 Topographic features and precipitation amounts for the Necanicum River watershed based on GIS calculations. Annual precipitation was estimated from the PRISM model (Daly et al. 1994).

Subwatershed	Subwatershed Area (mi^2)	Mean Elevation (ft)	Minimum Elevation (ft)	Maximum Elevation (ft)	Mean Annual Precipitation (in)
Beerman/Tillamook	15.8	423	0	1739	90
Klootchy/Mail Creek	15.3	669	56	2841	109
Neacoxie	7.4	42	3	390	74
North Fork/Humbug	13.7	904	171	2367	125
Seaside	8.3	212	0	1100	80
South Fork	9.9	1035	171	2846	132
Upper Necanicum	13.3	845	344	2417	128
Total	83.7	631	0	2846	108

4.2 Hydrologic Characterization

4.2.1 Watershed and Peak Flow Characterization

Peak Flow Processes

Peak flows occur as large quantities of water move from the landscape into surface waters. Peak flows occur in response to natural processes in the watershed and are characterized by the duration and volume of water during the rise and fall of a hydrograph. Most peak flows in the Coast Range are generated by high intensity rainstorms; the Coast Range generally develops very little snow pack. Snow pack that does develop in the coastal mountains is usually only on the highest peaks and is of short duration. Rain-on-snow events are infrequent in the Coast Range although these events have contributed to some of the major floods, including the floods of 1964 and 1996. These large floods are rare events, and the effects of land use practices on large floods in Oregon is currently the subject of much controversy. Past studies in the Coast Range found no appreciable increase in peak flows for the largest floods as a result of clearcutting (Rothacher 1971, 1973; Harr et al. 1975). However, more recent studies in Oregon have found increases in peak flows (Jones and Grant 1996). None of the Necanicum River subwatersheds have mean elevations above 2,000 feet, in the rain-on-snow zone, and the highest portions of the watershed are less than 3,000 feet elevation (Table 4.1). This hydrologic analysis therefore focuses on the effects of land use practices on the hydrology of these subwatersheds using rain events as the primary hydrologic process.

Snow pack is monitored at Saddle Mountain and Seine Creek to the south of the Necanicum watershed. The Saddle Mountain station is located at approximately 3,200 feet in elevation and has a mean snow water content of 6 inches (*http://www.wrcc.dri.edu*). The lower elevation site, Seine Creek, located at 2,000 feet, has a mean annual snow content of 2.5 inches and is periodic in nature. Less than 1 percent of the Necanicum River watershed is above 2,000 feet elevation and none is above 3,000 feet, suggesting that snow contributions to flooding only occur in extreme snow accumulation years.

Flooding is a natural process that contributes to both the quality and impairment of local environmental conditions. Consequently, flood management attempts to reduce flood hazards and damage while protecting the beneficial effects of flooding on the natural resources of the system. Flooding causes, impacts, and management options are discussed in the Tillamook Bay environmental characterization report (TBNEP 1998).

River flooding tends to occur most commonly in December and January during periods of heavy rainfall, which is occasionally accompanied by snowmelt. River flooding combined with tidal flooding can extend the flood season from November to February. The lowland valleys are the most prone to flooding during these periods.

The Necanicum River watershed has an extensive floodplain area (6 mi^2). An important natural function of the floodplain is to reduce the severity of peak flows, thereby reducing down-stream impacts and flood hazards. The Necanicum River floodplain occupies 7.2 percent of the watershed and plays an important role in regulating watershed hydrological function. The presence of large areas of intact palustrine and estuarine wetlands within this floodplain constitute an important resource in need of protection. These floodplain wetlands provide both hydrological and habitat values to the watershed.

4.2.2 Stream Flow

The Necanicum River was monitored for discharge by the USGS from 1953 to 1968 (*http://waterdata.usgs.gov/or/nwis*). The gage was located near Seaside. Daily flow data for this period are not available, although peak discharge measured during each water year is available (Table 4.2). Peak discharge was highly variable during the 16 year period of record, from a low of 1,310 cfs to 3,040 cfs. Peak discharge was less than or equal to 1,500 cfs during three years and greater than 3,000 cfs during two years of record. More recent flow data have been collected by the Oregon Water Resources Department, which has operated a stream gage

Table 4.2. Peak discharge for the Necanicum River for the period of record (1953-1968) at the USGS gaging station 14299000.

Water Year	Peak Discharge (cfs)	Water Year	Peak Discharge (cfs)
1953	1780	1961	1660
1954	2320	1962	1810
1955	1310	1963	1310
1956	3020	1964	3040
1957	1880	1965	1710
1958	1780	1966	2120
1959	2020	1967	2560
1960	1610	1968	1500

since 1977 (Figure 4.1). The Necanicum River demonstrates a typical coastal river discharge pattern with the majority of discharge occurring from November through April. Summer flows are low. The median (and 25th percentile) of the average daily flows for the period of record for the three driest months were as follows:

July - 10.2 cfs (8.7 cfs)
August - 5.8 cfs (4.5 cfs)
September - 11.0 cfs (6.6 cfs)

Flood events occur primarily in December through March. The highest discharge recorded for the period for both gages (USGS and OWRD) was 3,040 cfs (9.86 feet) in 1964, during one of the largest floods in North Coastal Oregon history.

4.3 Potential Land Use Impacts on Peak Flows

Increased peak flows can have deleterious effects on aquatic habitats by increasing streambank erosion and scouring (ODFW 1997a). Furthermore, increased peak flows can cause downcutting of channels, resulting in a disconnection of the stream from the floodplain. Once a stream is disconnected from its floodplain, the downcutting can be further exacerbated by increased flow velocities as a result of channelization.

All subwatersheds were screened for potential land use practices that may be influencing the hydrologic processes that contribute to increased peak flows and streambank erosion (WPN 1999). This screening process only deals with the most significant runoff processes affected by land use. There are four land use types that can have large effects on the hydrology of a

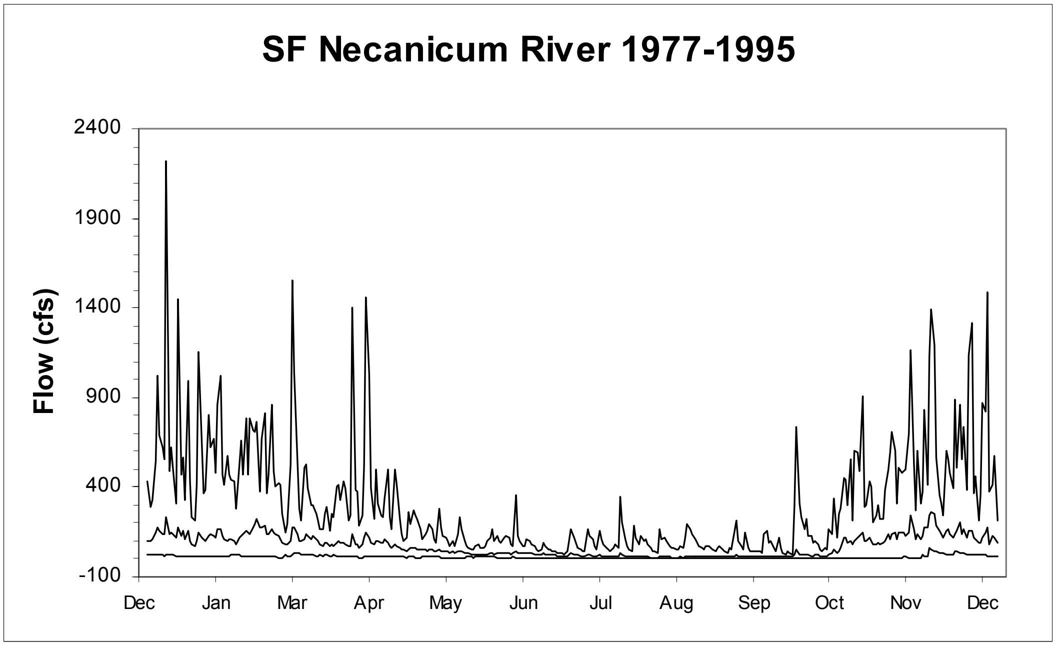


Figure 4.1. River discharge for the period of record, 1977 through 1995. The top line is maximum mean daily flow, the center line is mean daily flow, and the bottom line is minimum mean daily flow. (Data from ORWD)

watershed: forestry, agriculture and rangeland, forest and rural roads, and urban or rural residential development.

4.3.1 Forestry

Forestry practices have the potential to influence the magnitude of flooding, but it is difficult to quantify such effects because of the large natural variability in discharge (Hirsch et al. 1990). This difficulty has contributed to over a century of debate in the United States concerning the role of forest conservation in flood protection (Naiman and Bilby 1998). Studies in the Oregon Coast Range found no appreciable increase in peak flows during the largest floods that could be attributed to clearcutting (Rothacher 1971, 1973; Harr et al. 1975).

Although the largest floods are most important from a flood hazard standpoint and are frequently associated in watersheds of the Oregon Coast Range with rain-on-snow events, the effects of increases in smaller magnitude peak flows cannot be discounted from a stream channel or ecological standpoint (Naiman and Bilby 1998). High flows constitute a natural part of the stream flow regime and are largely responsible for transporting sediments and forming channels. Consequently, increases in the magnitude of moderate peak flows can lead to channel incision

through bank building or erosion. Because forest harvest practices are common in the watershed, there may be effects of forestry on watershed hydrology other than those commonly associated with rain-on-snow events. These might include reduced evapotranspiration, increased infiltration and subsurface flow, and increased overland flow (Naiman and Bilby 1998). Such changes may result in modified peak and low flow regimes and subsequent effects on in-stream aquatic habitat quality.

4.3.2 Agriculture and Rangeland

The impacts of agriculture on river hydrology are dependent upon specific land use and management practices as well as the physical characteristics of the soil being farmed. Those management practices that change the infiltration rate of the soils are the most influential in changing the hydrologic regime (WPN 1999). Agriculture has the greatest impact in those areas where soils have naturally high infiltration rates. However, only the Beerman/Tillamook subwatershed has any area of agricultural land use (1.8 percent). Consequently, there is not a significant potential for agricultural practices to change the infiltration rates of the soil to an extent that would appreciably affect the water budget of the watershed.

Other factors associated with agricultural land use that may have impacted the hydrology of the Necanicum River watershed include modifications to the stream system that affect water supply to wetlands and floodplain areas, such as river channel diking and draining of wetlands. Disconnection of floodplains from rivers reduces the flood attenuation provided by the floodplain's capacity to store and impede peak flows. Nonetheless, the Necanicum watershed is fortunate to have a relatively large proportion of floodplain and wetland area. Further discussion of disconnection of the floodplain and wetland loss can be found in Chapter 3 (Aquatic and Riparian Habitats).

4.3.3 Forest and Rural Roads

Road construction associated with timber harvest and rural development has been shown to increase wintertime peak flows of small to moderate floods in Oregon Coast Range watersheds (Harr 1983, Hicks 1990). This assessment uses a roaded area threshold of 8 percent to screen for potential impacts of roads on peak flows (discharge increase >20 percent; WPN 1999). Watersheds with a greater than 8 percent roaded area are considered to have a high potential for

adverse hydrologic impact, 4 to 8 percent have a moderate potential, and less than 4 percent have a low potential.

According to GIS calculations from the ODF fire roads coverage, all of the subwatersheds in the Necanicum River watershed were considered to have a low potential impact from the density of forest roads (Table 4.3). The average percent forested area in roads was only 2.6 percent. The Neacoxie subwatershed was highest, with 3.3 percent in roads. However, this GIS coverage may significantly under-estimate actual on-the-ground road conditions in the watershed. In a study conducted in the Oregon Mid-Coast watersheds (Garono and Brophy 1999), 1:24,000 road coverages under-represented actual road densities by 1.7 times. The GIS coverage was compared to a 1:24,000 road coverage for the area and it was determined that the results were fairly similar. If we doubled the estimated road densities in the Necanicum River subwatersheds, all of the subwatersheds would change to a moderate potential for peak flow enhancement as a result of forest road densities.

4.3.4 Urban and Rural Residential Areas

According to GIS calculations from the ODF fire roads coverage, almost all of the subwatersheds in the Necanicum River watershed were considered to have a high or moderate potential for adverse hydrologic impact from the density of rural residential roads (Table 4.4).

Table 4.3 Forest road summary for the Necanicum River watershed based on GIS calculations. The roads coverage data used for this analysis were obtained from the BLM (fire roads).

Subwatershed	Subwatershed Area (mi^2)	Area Forested (mi^2)	Forest Roads (mi)	Roaded Area (mi^2)[1]	Percent Forested Area in Roads	Relative Potential Impact
Beerman/Tillamook	15.8	13.60	78.24	0.37	2.72	Low
Klootchy/Mail Creek	15.3	14.89	82.06	0.39	2.61	Low
Neacoxie	7.4	1.29	8.94	0.04	3.28	Low
North Fork/Humbug	13.7	13.12	69.33	0.33	2.50	Low
Seaside	8.3	4.92	26.24	0.12	2.53	Low
South Fork	9.9	9.86	50.90	0.24	2.44	Low
Upper Necanicum	13.3	12.83	78.60	0.37	2.90	Low
Total	83.7	70.51	394.32	1.87	2.65	

[1] Width used to calculate roaded area was 25 ft.

Table 4.4 Rural residential road summary for the Necanicum River watershed based on GIS calculations. The roads coverage data used for this analysis were obtained from the BLM (fire roads).

Subwatershed	Subwatershed Area (mi^2)	Rural Residential Area (mi^2)[1]	Rural Roads (mi)	Roaded Area (mi^2)[2]	Percent Rural Area in Roads	Relative Potential for Peak-Flow Enhancement[3]
Beerman/Tillamook	15.8	0.32	7.51	0.04	10.98	High
Klootchy/Mail Creek	15.3	0.15	2.57	0.01	8.22	High
Neacoxie	7.4	1.34	7.29	0.03	2.58	Low
North Fork/Humbug	13.7	0.15	2.24	0.01	7.30	Moderate
Seaside	8.3	0.01	0.15	0.00	6.57	Moderate
South Fork	9.9	0.00	0.02	0.00	41.30	High
Upper Necanicum	13.3	0.10	1.56	0.01	7.46	Moderate
Total	83.7	2.06	21.34	0.10	4.90	Moderate

[1] Rural residential area includes rural areas not used for commercial purposes
[2] Width used to calculate roaded area was 25 ft.
[3] The relative potential for peak flow enhancement pertains only to the portion of each subwatershed in rural residential land use. The potential for peak flow enhancement from rural residential land use is moderate to high in many subwatersheds, but these designations only apply to a small area in each case.

The South Fork, Beerman/Tillamook and Klootchy/Mail Creek subwatersheds in particular, have high percentages (41, 11, and 8 percent respectively). It should be noted, however, that the South Fork subwatershed had very little land area in rural residential land use.

Urban land use is concentrated in the lower elevations of the watershed, generally in the floodplains of the Necanicum River. Historically, these floodplains were wetland areas that trapped sediments and accumulated plant material, resulting in rich fertile soils. Disconnecting part of the floodplain from the river has likely resulted in some loss of flood attenuation capacity, increased peak flows, down-cutting of channels, and increased flow velocities. Because the area involved is rather small, we do not expect that such changes have been substantial.

4.3.5 Other Potential Hydrologic Impacts

Past fires changed the ability of the surface soils to store runoff from forested areas (c.f., Coulton et al. 1996). Burned areas, and especially areas of repetitive burns, typically show a reduced ability to store moisture in surface soils (TBNEP 1998). Historical burns and

construction of salvage logging roads disrupted the infiltration and water storage capacity of upland areas. The loss of this natural flood attenuation mechanism, combined with the steep slopes and impermeable soils, may have increased the frequency and quantity of runoff and sediment delivery from heavy rainfall events. Landslides from natural slope failures or induced by road and culvert construction also added pulses of sediment to the river channels and changed the ability of the rivers to convey flood water (Coulton et al. 1996).

4.4 Conclusions

Screening for land management activities that may be affecting natural hydrologic conditions suggests that forest roads have little effect on current hydrologic regimes, but other hydrologic impacts may have occurred in response to urbanization in the valley bottom. Rural residential roads showed moderate to high potential for peak flow enhancement, but occupied relatively little land area, so their overall contribution to hydrologic impact is expected to be small at the watershed scale. Loss of historical flood plain acreage and land cover (such as wetlands, forested valley bottoms) have likely had some impacts on hydrologic conditions in the Necanicum River watershed. Logging and fires have likely resulted in lower evapotranspiration and therefore higher runoff. Such changes are expected to have been small in magnitude.

CHAPTER 5. WATER USE

Under Oregon law, all water is publicly owned. Consequently, withdrawal of water from surface and some groundwater sources requires a permit, with a few exceptions. The Oregon Water Resources Department administers state water law through a permitting process that issues water rights to many private and public users (Bastasch 1998). In Oregon, water rights are issued as a 'first in time; first in right' permit, which means that older water rights have priority over newer rights. Water rights and water use were examined for each of the water availability watersheds (watersheds defined by the Oregon Water Resources Department for the assessment of flow modification).

Water that is withdrawn from the stream has the potential to affect in-stream habitats by dewatering that stream. Dewatering a stream refers to the permanent removal of water from the stream channel, thus lowering the natural in-stream flows. For example, a percentage of the water that is removed from the channel for irrigation is permanently lost from that watershed as a result of plant transpiration and evaporation. In-stream habitats can be altered as a result of this dewatering. Possible effects of stream dewatering include increased stream temperatures and the creation of fish passage barriers.

Water availability basins are areas of land defined by the Oregon Water Resources Department (OWRD) that aid in the administration of state water rights. OWRD defines water availability as the amount of water that can be appropriated from a given point on a given stream for new out-of-stream consumptive uses. The location at which water is removed from a stream is called a Point of Diversion (POD). Because it may be impractical to calculate water availability for every POD within a watershed, water availability basins allow many PODs to be grouped within a defined watershed boundary. Within Oregon, OWRD has delineated 18 larger river basins that contain thousands of smaller water availability basins. The number and delineation of water availability basins depends on the location of gages and in-stream water rights and the physiography of affected streams.

Water is appropriated at a rate of withdrawal that is usually measured in cubic feet per second (cfs). For example, a water right for 2 cfs of irrigation allows a farmer to withdraw water from the stream at a rate of 2 cfs. Typically, there are further restrictions put on these water rights, including a maximum withdrawal amount allowed and the months that the water right can be exercised. Identifying all of these limits is a time-consuming and difficult task, which is

beyond the scope of this assessment. However, for subwatersheds identified as high priority basins, this might be the next step if water use is judged to pose a substantial problem.

The Oregon Water Resources Board (1975) rated watersheds throughout the Coastal Zone in terms of their water availability risk. Based on climatic and water use data, streamflows expected to occur 1 out of 2 years and 8 out of 10 years were estimated for coastal rivers. The Necanicum River was placed in the Extreme Risk category, which reflected demand in excess of average September (the most critical month) monthly flow during 1 out of every 2 years.

5.1 In-stream Water Rights

In-stream water rights were established by the Oregon Water Resources Department for the protection of fisheries, aquatic life, and pollution abatement. Four of the subwatersheds in the Necanicum River watershed currently have in-stream water rights (Table 5.1). The Necanicum River, North Fork Necanicum River, Klootchy Creek, and Bergsvik Creek all have in-stream water rights established in 1990 or 1991 by ODFW for the protection of anadromous and resident fish rearing. In addition, the Necanicum River has an in-stream water right established in 1973 for the protection of aquatic life. However, these water rights are junior to almost all of the other water rights in the watershed. Developing in-stream water rights that are more senior than current in-stream water rights would aid in the protection of in-stream flows in the Necanicum River watershed. This could be accomplished through water right trading and leasing through the Oregon Water Resources Department.

Table 5.1. In-stream water rights in the Necanicum River watershed. Data were obtained from the Oregon Water Resources Department.

Water Availability Watershed	Priority	Purpose
Necanicum River @ mouth	5/9/73 11/30/90	Supporting Aquatic Life Anadromous and Resident Fish Rearing
NF Necanicum River @ mouth	11/30/90	Anadromous and Resident Fish Rearing
SF Necanicum River @ mouth	10/11/91	Anadromous and Resident Fish Rearing
Klootchy Creek @ mouth	3/28/90	Anadromous and Resident Fish Habitat
Bergsvik Creek @ mouth	3/28/90	Anadromous and Resident Fish Habitat

5.2 Consumptive Water Use

5.2.1 Irrigation

Most of the sites for agricultural water withdrawal are located in the Seaside (6 sites) and Upper Necanicum (4 sites) subwatersheds (Figure 5.1). We are not aware of any of this agricultural water being used at the present time.

5.2.2 Municipal and Domestic Water Supply

The largest amount of water appropriated in the Necanicum River watershed is for municipal and domestic use by the City of Seaside (17.65 cfs; Table 5.2). Domestic points of diversion are scattered throughout the watershed, but most occur in the three lower subwatersheds (Figure 5.1). Municipal and domestic water supplies can have a large impact on in-stream flows, especially during low flow months. The City of Seaside, which resides adjacent to the Necanicum River estuary, draws its domestic water primarily from the South Fork Necanicum River and secondarily from the mainstem Necanicum River. During dry seasons, domestic water use combined with irrigation withdrawals may have deleterious effects on in-stream habitats by seriously reducing in-stream flows.

Table 5.2. Water use in the Necanicum River watershed. Data were obtained from the Oregon Water Resources Department

Water Availability Basin	Irrigation\ Agriculture (cfs)	Municipal / Domestic (cfs)	Fish/ Wildlife (cfs)	Industrial (cfs)	Livestock (cfs)	Total (cfs)
Bergsvik Creek @ mouth	-	0.01	0.50	-	-	0.51
NF Necanicum River @ mouth	-	0.02	-	-	-	0.02
SF Necanicum River @ mouth	-	8.00	-	-	-	8.00
Necanicum River @ mouth	3.24	1.42	1.61	0.02	0.02	6.31
Brandice Creek	-	0.60	-	-	-	0.60
Necanicum River @ Peterson Point	-	7.00	-	-	-	7.00
Unnamed Creek	-	0.60	-	-	-	0.60
TOTAL	3.24	17.65	2.11	0.02	0.02	23.04

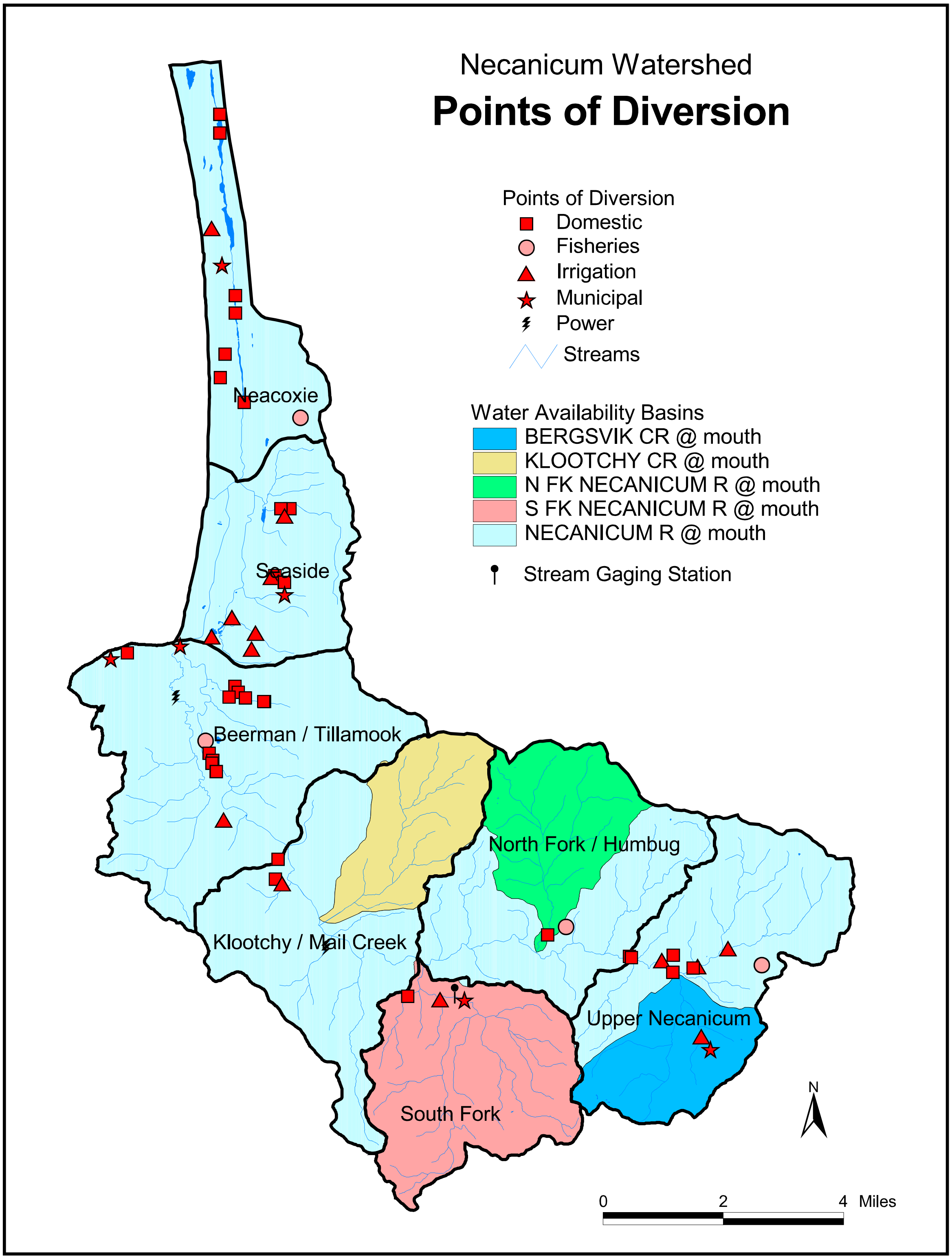


Figure 5.1. Water withdrawals in the Necanicum River watershed. Also shown are the locations of Water Availability Basins. The Necanicum River Water Availability Basin is a subsection of the Skipanon Water Availability Basin.

The City of Seaside has four separate water rights on the Necanicum River, as follows:

South Fork - 8 cfs (1924)

Mainstem @ Peterson Point - 7 cfs (1951)

Brandice Creek - 0.6 cfs (1965)

Unnamed Creek - 0.6 cfs (1965)

The main water right is on the South Fork. However, during low flow periods, the city does not withdraw more than 50 percent of the flow from that tributary. At such times, additional water is withdrawn from the mainstem at Peterson Point (Neal Wallace, City of Seaside, pers. comm., 2002).

5.3 Non-Consumptive Water Use

Significant amounts of water are also allocated for fish and wildlife (2.11 cfs, Table 5.2). The amount of water that has been appropriated for fish and wildlife in the Necanicum River watershed represents about one-fourth of the total water rights for the watershed. Most of that appropriation is in what we are designating as in the Necanicum River Water Availability Basin, which is a subsection of the Skipanon Water Availability Basin.

5.4 Water Availability

The Oregon Water Resources Department has developed models to assess the potential impacts of water withdrawals on stream flows (Robison 1991). These model outputs are available to the public on the OWRD website (*http://www.wrd.state.or.us*). They use predicted water loss based on the type of use for the appropriated water. Losses are then compared to predicted in-stream flows, based on a user- assigned exceedance level. We have chosen a 50 percent exceedance, which represents stream flows that would be expected at least 50 percent of the time.

Based on current water availability model output, there is significant concern for dewatering in the Necanicum River watershed. Three of the Water Availability Basins consistently demonstrated water loss greater than 20 percent of the predicted in-stream flows (Table 5.3). Consequently, it is likely that water withdrawals from the Necanicum River and its tributaries are having a large impact on current in-stream flows during summer and fall months. Dewatering potential was particularly evident in the South Fork Necanicum River subwatershed, which

Table 5.3. Dewatering potential in the Necanicum River watershed, based on a 50 percent exceedance*.

Water Availability Basin	Dewatering Potential (%)*					Overall Dewatering Potential	
	Jun	Jul	Aug	Sep	Oct	Average Percent Withdrawal	Potential
Necanicum River @ mouth	13.5	23.6	30.4	30.4	21.1	23.8	Moderate
Necanicum River above Klootchy Creek	11.8	20.8	28.0	29.3	19.3	21.8	Moderate
Bergsvik Creek @ mouth	0.0	0.0	0.0	0.0	0.0	0.0	Low
NF Necanicum River @ mouth	0.0	0.0	0.0	0.0	0.0	0.0	Low
SF Necanicum River @ mouth	45.5	78.2	106.7	107.4	72.3	82.0	High

* A 50% exceedance represents the amount of water than can be expected to be in the channel 50% of the time or one out of every two years.

showed a dewatering potential ranging from 72.3 percent to 107.4 percent during the months July through October. It is our recommendation that in-stream water rights continue to be protected and in-stream flows monitored during very low flow conditions.

Weber and Sheahan (1995) identified a problem with low water flows in the South Fork Necanicum River, which is dewatered during low flow months in some years. ODFW worked with the city of Seaside to attempt to provide additional summer and fall flows into 1.5 miles of the South Fork Necanicum River. An additional 7 miles of the mainstem Necanicum is also impacted below the confluence with the South Fork. A rather recent storage reservoir and filter plant gives the city flexibility to store additional water and/or pump directly from the lower river during low flow periods.

5.5 Conclusions

Appropriated water in the Necanicum River watershed represents a substantial fraction of modeled in-stream flows during the months June through October. Consequently, it is expected that surface water withdrawals generally have significant impacts on current in-stream habitat conditions. This suggests a potential for habitat degradation as a result of insufficient stream flow during low flow periods. Consequently, any surface water withdrawals during very dry months can exacerbate existing streamflow deficiencies. In-stream flow requirements for

salmonids should be further evaluated to determine actual impacts of surface water withdrawals on salmonid populations. Protection of in-stream flow for salmonid habitat is needed in the Necanicum River watershed.

CHAPTER 6. SEDIMENT SOURCES

6.1 Introduction

Erosion is a natural watershed process in the Oregon Coast Range. The bedrock geology of much of the Oregon Coast is composed of weak, highly erosive rock types. However, most experts agree that land use practices have increased the rate of erosion in many coastal watersheds (WPN 1999, Naiman and Bilby 1998). High levels of sediment in rivers and streams is associated with loss of agricultural lands and the filling of bays and estuaries. Sediment is also negatively impacting many aquatic organisms, including several species of salmon that are federally listed as threatened or endangered under the Endangered Species Act. Understanding the role of erosion and its interaction with other watershed processes is critical to maintaining a healthy ecosystem.

Most Pacific Northwest estuaries are depositional environments; they accumulate sediment (Komar 1997). Sediment in the Necanicum River Estuary comes from marine sources, the rivers and streams within the watershed, and from bayshore erosion (Glenn 1978).

Upland processes that deliver sediment to the stream system include landslides and surface erosion. In lowland streams and rivers, erosion occurs principally as streambank erosion. Wildfires alter soil conditions, setting the stage for increased rates of erosion. The majority of sediment deposition into the stream system occurs during large storm events. For example, the major floods of February, 1996 focused attention on the sediment accumulating in some coastal estuaries, which is perceived to be blocking rivers and channels in some places.

There were several assumptions made about the nature of sediment in this watershed (WPN 1999). First, sediment is a normal and critical component of stream habitat for fish and other aquatic organisms. Second, the more that sediment levels deviate (either up or down) from the natural pattern in a watershed, the more likely it is that aquatic habitat conditions will be significantly altered. Third, significant human-caused increases in sediment occur at a limited number of locations within the watershed, and these can be identified by a combination of site characteristics and land use practices. Finally, sediment movement is mostly episodic, with most erosion and downstream soil movement occurring during infrequent and intense runoff events.

Knowledge of current sources of sediment can provide a better understanding of the locations and conditions under which sediment is likely to be contributed in the future. These sources can then be evaluated and prioritized based on their potential effects on fish habitat and water quality to help maintain natural ecosystem functioning.

6.2 Screening for Potential Sediment Sources

OWEB has identified eight potential sediment sources that can have a significant impact on watershed conditions (WPN 1999). Not all are present in every watershed, and they vary in influence depending on where and how often they occur. The potential sediment sources identified by OWEB include slope instability, road instability, rural road runoff, urban area runoff, crop lands, range or pasture lands, burned areas, and other identified sources. The latter can include logging operations.

In this watershed, slope instability, road instability, and rural road runoff are the most significant sediment sources. Slope instability contributes to shallow landslides and deep-seated slumps, both of which are common in the Oregon Coast Range. Streamside landslides and slumps are major contributors of sediment to streams, and shallow landslides frequently initiate debris flows which can contribute large volumes of sediment and LWD to streams. Rural roads are a common feature of this watershed, and many are present on steep slopes. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads, especially unpaved gravel and dirt roads, indicates a significant potential for sediment contribution to the stream network.

Urban land runoff, as well as the history of fire in the watershed, are also potential contributing factors. However, urban lands occupy a small portion of the watershed on generally level terrain and are not expected to be major contributor of sediment in this watershed. Developed lands (urban and rural residential) occupy about 6 percent of the Necanicum River watershed.

6.3 Slope Instability

Landslides are the main source of sediment in the Oregon Coast Range. A landslide is defined as “the movement of a mass of rock, debris, or earth down a slope” (National Research Council 1996). Often, landslides gather large amounts of organic material, such as downed logs and woody debris, as they travel downslope. They are extremely variable in size and velocity, usually falling into two categories: “shallow-rapid” and “deep-seated” (Washington Forest Practices Board 1995). Shallow-rapid landslides are typical on steep forested hillslopes (Mills 1997). Shallow rapid landslides include rock slides, debris slides and debris flows. A small debris slide (generally occurring on steep slopes with shallow soils) becomes a debris flow if the sliding soil, moving downslope, scours and entrains additional soil and vegetation in its path. In

areas with steep slopes, debris flows are the dominant erosional mechanism (Mills 1997). Deep-seated landslides are more commonly slow-moving and are also highly variable in size.

Under natural conditions, geology, topography, and climate interact to initiate landslides. With human intervention, natural conditions may be modified in ways that increase the likelihood of landslide initiation. Road-building often creates cuts and fills. In a slide-prone landscape, road-cuts may undercut slopes and concentrate runoff along roads, and road-fills on steep slopes may give way, initiating a landslide (NRC 1996). Vegetation removal, such as by logging or wildfire, may also increase the likelihood of landslide occurrence.

Landslides and debris flows can have positive and negative effects on fish in streams. A landslide from a forested hillside will contain mineral soil, organic material, and a substantial amount of LWD. This mixture causes significant changes in the affected stream reach (Chesney 1982). In the short term, a debris flow can scour a channel or remove beneficial prey (benthic macroinvertebrates) and channel structures. Over the long-term, these events deliver woody debris, organic matter, and gravel that could result in the reestablishment of productive aquatic habitat and provide an important reset mechanism to the stream ecosystem.

There are few estimates of sediment yield from forest lands in the north coast region. To date, no comprehensive aerial photo or on-the-ground inventories of landslides have been conducted in the Necanicum River watershed. Landslide data are collected by Willamette Industries within the watershed, but these data were not available in digital form for inclusion in this assessment. Upland erosion rates in the watershed are likely to have increased due to human activities, but the exact amount of increase is unclear. In 1999, the Oregon Department of Forestry compiled and mapped landslide information from state and federal agencies for all of western Oregon. However, no landslides were recorded in the Necanicum River watershed, because nearly all steep, forested terrain in this watershed is privately owned, and landslide data from the landowners were not available.

ODF created debris flow hazard maps in 1996 to characterize the potential for future landslide activity based on watershed features such as slope, soils, and geology. According to these maps, about one-quarter of the Necanicum River watershed is in the debris flow activity zone (Figure 6.1). Most of that land (22 percent of the watershed) is in the moderate hazard zone; only 4 percent was classified as high risk (Table 6.1). The subwatersheds having greatest

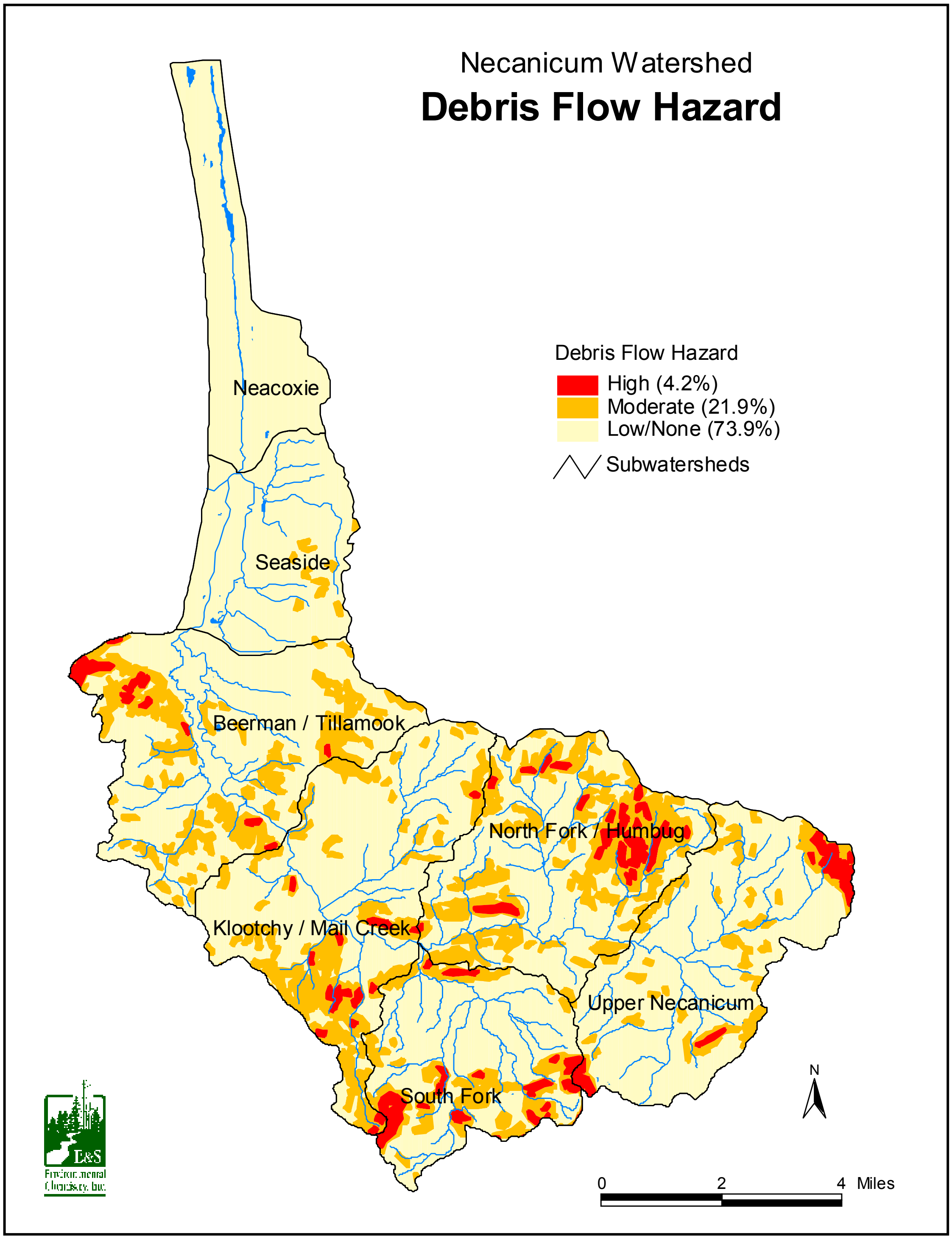


Figure 6.1 Debris flow hazard zones for the Necanicum River watershed.

Table 6.1. Potential debris flow hazard zones in the Necanicum River watershed.

		Debris Flow Hazard Risk		
Subwatershed	Area (sq. mi.)	High (%)	Moderate (%)	High+Mod (%)
Beerman/Tillamook	15.7	3.0	27.7	30.7
Klootchy/Mail Creek	15.3	3.2	27.6	30.8
Neacoxie	7.3	0.0	0.0	0.0
North Fork/Humbug	13.7	8.0	37.2	45.2
Seaside	8.3	0.0	4.1	4.1
South Fork	9.9	8.6	22.7	31.3
Upper Necanicum	13.3	4.6	15.1	19.7
TOTAL	83.5	4.2	21.9	26.1

risk are North Fork/Humbug and South Fork; each had \$ 8 percent high hazard and \$ 23 percent moderate hazard. Neacoxie is the only subwatershed completely outside of the debris flow risk zone.

6.4 Road Instability

Roads constitute the primary source of increased sediment from forestry-related activities in the western United States (Mills 1997). Landslide frequency can be greatly accelerated by road building and management practices (Sidle et al. 1985). Road construction, especially on steep slopes, can lead to slope failure and result in increased landslide activity (WPN 1999, Sessions et al. 1987). Road stability is partially determined by the method of construction. For example, sidecast roads are built by using soil from the inside portion of a road to build up the outside, less stable portion of the road. Sidecast roads work well in moderately steep terrain, but in steep terrain the sidecast material frequently slides off the roadbed, initiating landslides or debris flows. Road crossings with poorly designed culverts can fail and wash out, create gullies, and deliver large pulses of sediment to the channel. Sediment delivery to streams depends on the percentage of the road drainage system which discharges directly to the channel; the proximity of non-stream discharges (*i.e.*, discharges across the hillside) to a channel; the volume of water involved and the potential for gully development (stream extension); and the volume of eroded material available (Mills 1997).

We also constructed a GIS-based analysis of road-stream crossings. We found an average density of 3.2 crossings per square mile in the Necanicum River watershed. The highest densities were in the South Fork and Seaside subwatersheds, with 4.4 and 4.2 crossings per square mile, respectively. The lowest density was 0.8 crossings/sq. mi. in the Neacoxie subwatershed (Table 6.2).

Table 6.2. Stream/road crossings in the Necanicum River watershed. Data were calculated using GIS.

Subwatershed	Area (sq. mi.)	Road-Stream Crossings	
		(#)	(#/sq. mi)
Beerman/Tillamook	15.7	60.0	3.8
Klootchy/Mail Creek	15.3	40.0	40.0
Neacoxie	7.3	6.0	0.8
North Fork/Humbug	13.7	45.0	3.3
Seaside	8.3	35.0	4.2
South Fork	9.9	43.0	4.4
Upper Necanicum	13.3	40.0	3.0
TOTAL	83.5	269.0	3.2

In 1997, Willamette Industries Inc. developed a forest road inventory in conjunction with the Oregon Department of Forestry and the Oregon Forest Industries Council. The North Coast Resource Area inventoried approximately 1700 miles of road on company managed forestland in Tillamook, Columbia, and Clatsop Counties. Road features were given a priority class from one to five, with one being highest priority for repair and five being no action needed.

In 1999, the road inventory had been completed and a legacy road improvement and decommissioning plan was developed. The plan recommends that all road segments identified as needing action should either be repaired or decommissioned within the next 10 years. The plan breaks the road inventory priorities into subclasses. The subclasses, in order of singular impact or concern, are safety, sedimentation into live streams, mass wasting, sedimentation depositing outside of live streams and fish passage. As an example of the structure of this system, a priority-one road with a safety concern will be repaired/decommissioned before a priority-one road that has fish passage issues. Under the North Coast Resource Area 10-year road plan, all priority one road segments were scheduled to be repaired/decommissioned by the

fall of 2001, and all road segments requiring action will be repaired/decommissioned by the fall of 2008.

Recent concern about sediment from road systems entering waters of the state has prompted Willamette Industries, Inc. to adopt new specifications for forest road location, construction and reconstruction, maintenance and erosion control. Whenever possible, existing roads that parallel stream channels are relocated or bypassed and new roads are located near ridge tops to minimize the number of stream crossings. This method of road location helps minimize the possibility of sediment entering streamwaters. Ditch relief culverts or ditchouts are placed with a minimum spacing of 300-500 feet. Ditch relief culverts are placed 50 to100 feet ahead of all stream crossing culverts. This allows ditch water to filter through vegetation on the forest floor prior to entering flowing water. Stream crossing culverts are required to be designed to pass a 50 year flood event. However, all crossings installed by the North Coast Resource Area will pass a 100 year event. Side-cast material in steeper terrain that has the potential to fail is pulled back and the road is set into the hillside. All waste material in these steeper areas in now hauled to stable waste areas.

All-weather haul roads are now surfaced with quarried rock and the top lift is usually a finer grade crushed rock that has been processed with a grader and vibratory roller. By processing the rock, the road surface is sealed and water cannot saturate the subgrade. This helps prevent the "pumping" of mud onto the road surface. Roads with natural surfaces have haul restrictions placed on them and active haul is allowed only during periods of dryer weather. All active haul roads are continually monitored and maintained. If a road begins to show signs of failing, active hauling will be suspended until the road can be repaired. All non-active haul roads are monitored on an annual basis and during periods of high flows, with routine maintenance performed as needed.

Where there is potential for erosion, a variety of erosion control methods are used. Silt fences and straw bales are used along with settling basins to help slow water and allow suspended sediment to settle out of the water. Seeding and hand mulching or hydro mulching are used to vegetate surfaces to prevent erosion.

6.5 Road Runoff

Water draining from roads can constitute a significant sediment source for streams. However, the amount of sediment potentially contained in road runoff is difficult to quantify,

because road conditions and the frequency and timing of use can change rapidly. Poor road surfaces that are used primarily in dry weather may have a smaller impact on sediment production than roads with higher quality surfaces that have higher traffic and are used primarily in the rainy season. Road data were used to assess potential sediment contribution from road runoff. Road density within 200 feet of a stream and on slopes greater than 50 percent was calculated using GIS.

The density of roads within 200 feet of a stream was highest in the Beerman/Tillamook subwatershed, at 0.59 miles of road per mile of stream, while the lowest was in the Neacoxie subwatershed, at 0.17 miles of road per mile of stream. The most common road surface in the Necanicum River watershed is gravel, accounting for approximately three-fourths of all roads in the basin. Dirt roads account for 7 percent all roads, and 18 percent of roads are paved (Table 6.3).

Table 6.3. Current road conditions in the Necanicum River watershed. The ODF fire roads coverage was used to calculate these numbers in GIS (see GIS data evaluation).

Subwatershed	Stream Length (mi)	Road Length (mi)	Gravel (%)	Dirt (%)	Paved (%)	Roads <200' from Stream (mi)	(mi/mi*)	Roads <200' from Stream and >50% Slope (%)
Beerman/Tillamook	25.3	96.4	80.7	4.6	14.7	15.00	0.59	1.04
Klootchy/Mail Creek	26.6	86.5	93.6	1.2	5.3	9.94	9.94	0.47
Neacoxie	7.1	40.2	46.0	0.6	53.5	1.23	0.17	-
North Fork/Humbug	31.1	76.1	88.1	7.1	4.8	8.52	0.27	0.51
Seaside	19.0	68.7	40.7	2.6	56.7	5.78	0.30	0.20
South Fork	26.8	51.3	82.0	18.0	-	9.44	0.35	1.09
Upper Necanicum	27.5	84.1	72.7	15.2	12.2	10.79	0.39	0.32
Total	163.4	503.3	74.6	6.9	18.5	60.70	0.37	0.55

* Units are miles of road per mile of stream

Very few roads in the Necanicum River watershed are both within 200 feet of a road and located on a hillside slope gradient greater than 50 percent, based on GIS analysis. The Beerman/ Tillamook and South Fork subwatersheds were the only subwatersheds that had more than 1 percent of their roads on very steep slopes and within 200 feet of a stream (Table 6.3). On average, only 0.55 percent of the roads in the Necanicum watershed were judged to be both on

steep slope and close to a stream. It must be noted, however, that slope calculations based on DEMs tend to under-represent slope steepness.

6.6 Streambank Erosion

Erosion in agricultural and urban lowlands typically takes two forms: streambank cutting, and sheet and rill erosion (Pedone 1995). Streambank erosion is the more prevalent of the two types (USDA 1978). Significant streambank erosion typically takes place due to selective stratigraphic failure, soil saturation, and sloughing during high flow events (USDA 1978). Increased bank erosion is commonly associated with the removal of riparian vegetation. Cattle accessing streambanks can also increase erosion when their hooves break up the soil matrix and remove vegetation (USDA 1978). Sheet and rill erosion is most common along unvegetated road cuts and fills, but also occurs on construction sites and roadbeds, and can contribute significant amounts of sediment in localized areas.

Thirty-two miles of streams were surveyed by ODFW in the Necanicum River watershed. Of these, on average 39 percent of the surveyed length had experienced streambank erosion. The Beerman/Tillamook subwatershed experienced the highest proportion of streambank erosion (65 percent). ODFW surveyed streams accounted for 19 percent of the length of the stream network.

Agricultural and urban lowlands occupy only approximately 4.2 percent of the Necanicum River watershed. We do not expect, therefore, that erosion in lowland portions of the watershed is a major contributor to the overall sediment budget of the Necanicum River watershed. As in upland streams, non-organic sediment plays an important role in lowland stream channel morphology. Organic sediment, including wood, contributes to channel structure, and to the aquatic habitat and food resources of the fluvial ecosystem. Human uses of the lowlands have affected the rate and character of lowland sedimentation through changes in flooding frequency and size, and by the diking or draining of floodplains and wetlands. In addition, channel modification, removal of LWD, and streamside grazing have increased streambank erosion. These changes have in turn affected the quantity and quality of riparian and aquatic habitat in the lowlands.

6.7 Conclusions

Sediment in the rivers and streams of the Necanicum River watershed is an issue of concern. The combination of the wet climate, steep slopes in some portions of the uplands, and erosive

soils results in naturally moderate to high levels of sediment in the rivers and streams. Historic wildfires in the watershed, as well as resource management practices over the past century, are believed to be associated with an additional increase in sediment levels. High levels of sediment in the streams may result in increased rates of sedimentation in the estuary. Additionally, high sediment levels are associated with the declining health of salmonid populations. Whereas naturally occurring sources of sediment in the watershed are uncontrollable and in fact are beneficial, the additional sediment contributed by human activity may contribute to habitat degradation.

Based on the debris flow hazard analysis (Figure 6.1), landslide frequency in the Necanicum River watershed is probably not very high compared to other coastal watersheds. However, a comprehensive landslide inventory of the watershed is lacking, and the specific locations of landslide activity are unknown.

Roads are the primary source of sediment related to human activity. Contribution of sediment from roads is attributed to two processes: landslides originating from roads, and road runoff. Landslides coming from roads produce the largest proportion of road-associated sediment. The high density of stream-crossing culverts on sidecast dirt and gravel roads suggests that road-associated landslides are of concern in the Necanicum River watershed. Cooperation with private landowners to identify and improve sediment sources on private roads will further mitigate the impact of sediment in the watershed.

Lastly, streambank erosion is a concern in the Necanicum River watershed. While the overall contribution of sediment from streambank erosion is typically less significant that other sources, erosion from the streambank is associated with a lack of riparian shade. Restoration of riparian vegetation will lessen sediment contribution from streambank erosion.

CHAPTER 7. WATER QUALITY

7.1 Introduction

The purpose of the water quality assessment, according to the OWEB manual (WPN 1999), is to complete a screening-level analysis of water quality. A screening-level analysis serves to identify obvious areas of water quality impairment by comparing selected measurements of water quality to certain evaluation criteria. The screening-level analysis uses existing data obtained from a variety of sources. This assessment does not include statistical evaluation of seasonal fluctuations or trends through time, and does not evaluate specific sources of pollution through upstream/downstream comparisons.

7.1.1 Assessment Overview

The water quality assessment proceeds in steps. The first step is to identify uses of the water that are sensitive to adverse changes in water quality, and identify potential sources of pollution in the watershed. The second step establishes the evaluation criteria. The third step examines the existing water quality data in light of the evaluation criteria. Conclusions can then be made about the presence of obvious water quality problems in the watershed, and whether or not additional studies are necessary.

Water quality is evaluated by comparing key indicators against evaluation criteria. Indicators are selected to represent pollution categories. Some aspects of water quality, such as fine sediment and temperature processes, are addressed in other sections of this watershed assessment. Although there are many constituents that contribute to the water quality of a stream, the watershed assessment is focused on seven that are most often measured, and that may have the most direct effect on aquatic organisms: temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity, and chemical contaminants. Evaluation criteria, discussed in Section 7.4, have been determined based on values of these constituents that are generally protective of aquatic life.

7.1.2 Components of Water Quality

<u>Temperature</u>

Cool water temperatures are necessary for the survival and success of native salmon, trout, and other aquatic life. Excessively warm temperature can adversely affect the survival and

growth of many native species. Although there is some debate about which specific temperatures should apply, and during which part of the year, standards have been set that can be used to determine if the waters in the stream are too warm. Because temperature in the stream varies throughout the day and among the seasons, multiple measurements throughout the day and in different seasons are needed to adequately assess water temperature conditions.

Dissolved oxygen

Aquatic organisms need oxygen to survive. Oxygen from the air dissolves in water in inverse proportion to the water temperature. Warmer water contains less dissolved oxygen at saturated conditions. Organisms adapted to cool water are usually also adapted to relatively high dissolved oxygen conditions. If the dissolved oxygen is too low, the growth and survival of the organisms is jeopardized. As with temperature, dissolved oxygen can vary throughout the day and among the seasons, so multiple measurements, both daily and seasonally, are required for an adequate analysis of water quality conditions.

pH

The pH is a measure of the acidity of water. The chemical form and availability of nutrients, as well as the toxicity of pollutants, can be strongly influenced by pH. Pollutants can contribute to changes in pH as can the growth of aquatic plants through photosynthesis. Excessively high or low pH can create conditions toxic to aquatic organisms.

Nutrients

Nitrogen and phosphorus, the most important plant nutrients in aquatic systems, can contribute to adverse water quality conditions if present in too great abundance. Abundant algae and aquatic plant growth that results from high nutrient concentration can result in excessively high pH and low dissolved oxygen, can interfere with recreational use of the water, and, in some cases, can produce toxins harmful to livestock and humans.

Bacteria

Bacterial contamination of water from mammalian or avian sources can cause the spread of disease through contaminated shellfish, contact recreation or ingestion of the water itself. Bacteria of the coliform group are used as an indicator of bacterial contamination.

Turbidity

Turbidity is a measure of the clarity of the water. High turbidity is associated with high suspended solids, and can be an indicator of erosion in the watershed. At high levels, the ability of salmonids to see their prey is impaired. As discussed elsewhere, high suspended sediment can have a number of adverse effects on fish and aquatic organisms.

Chemical contaminants

Synthetic organic compounds, pesticides, and metals can be toxic to aquatic organisms. The presence of such contaminants in the water suggests the presence of sources of pollution that could be having an adverse effect on the stream ecosystem.

7.2 Beneficial Uses

The Clean Water Act requires that water quality standards be set to protect the beneficial uses that are present in each water body. ODEQ has established the beneficial uses applicable to the 18 major river basins in the State. The Necanicum River watershed is in the North Coast Basin. The beneficial uses established for all streams and tributaries in the basin are (OAR 340-41-202):

Public domestic water supply[1]
Private domestic water supply[1]
Industrial water supply
Irrigation
Livestock watering
Anadromous fish passage
Salmonid fish rearing
Salmonid fish spawning
Resident fish and aquatic life
Wildlife and hunting
Fishing
Boating
Water contact recreation
Aesthetic quality

Estuaries and adjacent marine waters are considered to support the above beneficial uses as well, not including public or private water supply, irrigation, or livestock watering. Water quality must be managed so the beneficial uses are not impaired.

Not all beneficial uses are equally sensitive to change in water quality. For example, use of the water body for domestic water supply would be impaired long before its use for commercial navigation. In general, water quality is managed to protect the most sensitive beneficial use. In

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

the case of the Necanicum River watershed, the most sensitive beneficial use is probably salmonid fish spawning. It is assumed that if the water quality is sufficient to support the most sensitive use, then all other less sensitive uses will also be supported.

7.3 Pollutant Sources

7.3.1 Point Sources

The Clean Water Act prohibits discharge of waste to surface water. In order to discharge any waste, a facility must first obtain a permit from the State. ODEQ issues two primary types of discharge permit. Dischargers with Water Pollution Control Facility (WPCF) permits are not allowed to discharge to a water body. Most WPCF permits are issued for on-site sewage disposal systems. Holders of National Pollutant Discharge Elimination System (NPDES) permits are allowed to discharge wastes to waters of the state, directly or indirectly, but their discharge must meet certain quality standards as specified in their permits. Permits set limits on pollutants from industrial and municipal dischargers based on the ability of the receiving stream to absorb and dissipate the pollutants. Industries, municipal wastewater treatment facilities, fish hatcheries, and similar facilities typically have NPDES permits. General permits are issued to certain categories of discharger rather than to individual facilities. The current discharge permits for the Necanicum River watershed are listed in Table 7.1.

7.3.2 Non-point Sources

The largest current source of pollutants to Oregon’s waters is not point sources such as factories and sewage treatment plants. The largest source of water pollution comes from surface water runoff, often called “non-point source” pollution. Rainwater, snowmelt, and irrigation water flowing over roofs, driveways, streets, lawns, agricultural lands, construction sites, and logging operations carries more pollution, such as nutrients, bacteria, and suspended solids, than discharges from industry.

Water quality is affected by the introduction of organic matter to streams. The presence of organic matter increases biochemical oxygen demand, which means less dissolved oxygen is available for aquatic life. The introduction of untreated animal or human waste increases the possibility of bacterial contamination of water, increasing the risk of infection to swimmers. Eutrophication is the process of enrichment of water with nutrients, mainly nitrogen and

Table 7.1. Permitted facilities listed by ODEQ that have discharges to surface water in and around the Necanicum River watershed (ODEQ 2000).[1]

Facility Name	Category	Latitude	Longitude	Type	RM
Arch Cape Sewage Treatment Plant	Domestic	45.80330	123.95310	NPDES	0.5
Ready Mix Division - Gearhart	Industrial	45.92310	123.54000	GEN12A	0
Square Creek Quarry - Cannon Beach	Industrial	46.01670	123.94840	GEN12A	5.2
Park Drive Plaza	Domestic	46.02500	123.91120	GEN51	0
Laurelwood Farm Composting Facility	Industrial	45.91980	123.89390	GEN12C	9
Laurelwood Farm Composting Facility	Industrial	45.91980	123.89390	GEN12Z	9
Cannon Beach Sewage Treatment Plant	Domestic	45.89580	123.94840	NPDES	0
Don's Union Service (Inactive)	Industrial	45.98330	123.91670	GEN15A	2.3
Johnson Quarry	Industrial	45.95010	123.91980	GEN12A	6.3
Captain Morgan's Restaurant	Domestic	46.03640	123.91330	GEN52A	0.2
Pinehurst Estates	Industrial	46.05560	123.92530	GEN12C	0.4
Seaside Sewage Treatment Plant	Domestic	46.00830	123.92230	NPDES	0.2

[1] The type of discharge allowed by each permit can be found by examining the individual permit. Permits can be accessed through the ODEQ website at *http://www.deq.state.or.us/wq*.

phosphorous compounds, which results in excessive growth of algae and nuisance aquatic plants. It increases the amount of organic matter in the water and also increases pollution as this matter grows and then decays. Through photosynthesis, algae and aquatic plants consume carbon dioxide (thus raising pH) and produce an abundance of oxygen. At night the algae and plants respire, depleting available dissolved oxygen. This results in large variations in water quality conditions that can be harmful to other aquatic life. While natural sources of nutrients can influence eutrophication, the introduction of nutrients strengthens the process.

Sources of nutrients include wastewater treatment facility discharge and faulty septic systems, runoff from animal husbandry, fertilizer application, urban sources, and erosion. High water temperatures compound the decline in water quality by causing more oxygen to leave the water and by increasing the rate of eutrophication. Removal of streamside vegetation, among other factors, influences high stream temperature and, via erosion, increases sedimentation of streams.

Land use can have a strong influence on the quantity and quality of water flowing from a watershed. An undisturbed watershed with natural vegetation in and along streams and rivers and a diversity of habitats on the uplands provides clean water that supports the desirable beneficial uses of the waterway. As the watershed is affected by activities such as logging, agriculture, and urban development, the water quality in the waterways can become degraded. The percent of the land area of the Necanicum River watershed affected by these land uses is shown in Table 7.2. Table 1.4 shows the distribution of all land use types in the watershed.

Table 7.2. Percent area of the Necanicum River watershed by selected land uses.

Land Use Type	Area (sq mi)	Percent of Total Area
State Forest	1.50	1.79
Private Industrial Forest	69.01	82.45
Agriculture	0.56	0.66
Developed	5.04	6.02
Other	7.59	9.07

The most prominent type of land use in the Necanicum River watershed is forested, with relatively little land in developed areas or agriculture. This land use pattern suggests that water quality problems associated with toxic industrial chemicals may be of relatively little importance while problems associated with sediment, turbidity, temperature, and possibly bacteria are likely to be more important. To the extent that herbicides and pesticides are used in forestry and agriculture operations, these compounds may assume greater importance.

7.3.3 Water Quality Limited Water Bodies

Sometimes, applying the best available treatment technology to all the point sources in a basin does not bring the stream into compliance with water quality standards. The combination of pollutants from all sources, point and non-point, within the watershed may contribute more pollution than the stream can handle. Under this circumstance, when a stream consistently fails to meet water quality standards for a particular pollutant, it is declared by ODEQ to be "water quality limited" as required by the Clean Water Act Section 303(d). Water bodies on the "303d List" must be analyzed to determine the total amount of pollutant that can be accommodated by the stream (the total maximum daily load –TMDL). This load is then allocated to all the dischargers, including non-point. Dischargers must then take the steps necessary to meet their

allocated load. The water quality limited water bodies in the Necanicum River watershed are listed in Table 7.3.

Table 7.3. Water quality limited water bodies in the Necanicum River watershed (DEQ 1999).

Water Body	Segment	Parameter	Season
Necanicum River	Mouth to Headwaters	Bacteria	Summer

7.3.4 Oregon Water Quality Index

Although the 303(d) list identifies water bodies that are known not to meet current water quality standards, the list is not necessarily a complete indicator of water quality in a particular basin. For many stream reaches there are not enough data to make a determination. In addition, the 303(d) listing is tied to the total amount of monitoring done, which is influenced by the number of special monitoring studies completed by ODEQ. Because special studies are frequently concentrated where water quality degradation is a concern, the sampling is weighted toward poorer quality waters. Consequently the ODEQ has developed the Oregon Water Quality Index (OWQI) as a water quality benchmark that is keyed to indicator sites monitored regularly by ODEQ.

The OWQI integrates measurements of eight selected water quality parameters (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia+nitrate nitrogen, total phosphates, total solids, fecal coliform) into a single index value that ranges from 10 (the worst) to 100 (the best). Land use, geology, hydrology, and water quality vary widely throughout the North Coast basin. Oregon Water Quality Index (OWQI) values for some streams in the North Coast basin are included in Table 7.4. Water quality in the Necanicum River is good to excellent according to the OWQI, and generally as good as, or better than, water quality in other near-by rivers (Table 7.4).

7.3.5 Data Sources

In order to assess more adequately the water quality conditions in the Necanicum River watershed, we assembled available data from a variety of sources. Data were obtained from the EPA STORET[2] database for the period 1967 through 1998 and from the ODEQ LASAR

[2] STORET data are available on CD-ROM from Earth Info, Inc. 5541 Central Ave., Boulder, CO 80301; (303) 938-1788.

Table 7.4. Seasonal Average OWQI Results for the Necanicum River, along with selected additional rivers in the North Coast Basin for comparison purposes (WY 1986 - 1995).

Site	STORET Number	River Mile	Summer Average	FWS Average	Minimum Seasonal Average
Necanicum River	402191	5.8	89	91	89
Miami R. @ Moss Ck. Rd.	412120	1.7	81	86	81
Wilson R. @ HWY 6	412133	8.5	91	90	90
Wilson R. @ HWY 101	412130	1.8	82	82	82
Skipanon R. @ Hwy 101	402489	4.9	70	76	70
Nehalem R. @ Foley Rd.	404545	7.8	89	84	84
Lewis and Clark R. @ Stavebolt Ln.	402494	7.6	88	78	78

Summer: June - September; FWS (Fall, Winter, & Spring): October -May
Scores - Very Poor: 0-59, Poor: 60-79, Fair: 80-84, Good: 85-89, Excellent: 90-100

database (*http://www.deq.state.or.us/wq/lasar/lasarhome.htm*) for 1967 through 2000. In addition, temperature data were collected from six sites in the Necanicum watershed by members of the Necanicum River Watershed Council.

7.4 Evaluation Criteria

The evaluation criteria used for the watershed assessment are based on the Oregon Water Quality Standards for the North Coast Basin (ORS 340-41-205) and on literature values where there are no applicable standards, as for example, for nutrients (WPN 1999). They are not identical to the water quality standards in that not all seasonal variations are included. The evaluation criteria are used as indicators that a possible problem may exist. The evaluation criteria are listed in Table 7.5.

The water quality evaluation criteria are applied to the data by noting how many, if any, of the water quality data available for the assessment exceed the criteria. If sufficient data are available, a judgement is made based on the percent of values that exceed the criteria as shown in Table 7.6. If insufficient, or no, data are available, it is noted as a data gap to be filled by future monitoring. If any water quality parameter is rated as “moderately impaired” or

Table 7.5. Water quality criteria and evaluation indicators (WPN 1999).

Water Quality Attribute	Evaluation Criteria
Temperature	
Salmonid spawning	Daily maximum of 55° F (17.8° C) (7-day moving average)
Salmonid rearing	Daily maximum of 64° F (17.8° C) (7-day moving average)
Dissolved Oxygen	
Salmonid spawning	11.0 mg/L
Salmonid rearing	8.0 mg/L
pH	Between 6.5 and 8.5 units
Nutrients	
Total Phosphorus	0.05 mg/L
Total Nitrate	0.30 mg/L, as N
Bacteria	Water-contact recreation 126 E. coli/100 mL (30-day log mean, 5 sample minimum) 406 E. coli/100 mL (single sample maximum) Marine water and shellfish areas 14 fecal coliform/100 mL (median) 43 fecal coliform/100 mL (not more than 10% of samples)
Turbidity	50 NTU maximum
Organic Contaminants	Any detectable amount
Metal Contaminants	
Arsenic	190 µg/L
Cadmium	0.4 µg/L
Chromium (hex)	11.0 µg/L
Copper	3.6 µg/L
Lead	0.5 µg/L
Mercury	0.012 µg/L
Zinc	32.7 µg/L

Table 7.6. Criteria for evaluating water quality impairment (WPN 1999).

Percent of Data Exceeding the Criterion	Impairment Category
Less than 15%	No impairment
15 to 50%	Moderately impaired
More than 50%	Impaired
Insufficient data	Unknown

"impaired", water quality in the stream reach in question is considered impaired. The condition that caused the impairment should be addressed through stream restoration activities.

7.5 Water Quality Data

7.5.1 STORET

Data were obtained from the EPA STORET database for the period 1965 through 1998. There were 112 sites in the USGS hydrologic unit 1710020101, which includes the Necanicum River, that had water quality data in the STORET database. Of these 112 sites, 50 were from ambient stream stations. The remaining sites were from such locations as point discharges, wells, sewers, pump stations, and similar locations.

Sites sampled only once over a period of 30 years do not provide adequate data to make judgements about water quality. For this reason, only sites that had been sampled multiple times were used in this analysis. There were 16 sites in the watershed that had been sampled more than once since 1966. The sites sampled more than once are listed in Table 7.7 and displayed in Figure 7.1.

7.5.2 ODEQ Sites

ODEQ currently maintains one site in the Necanicum River watershed in Seaside at Riverside Lake Camp (RM 5.8) as part of their ambient water quality monitoring network This site is the most frequently sampled, and is the STORET site with the most recent data. Additional sites in the watershed have been sampled occassionally by ODEQ for various special studies. Data for these sites were obtained from the ODEQ laboratory database (LASAR). Table 7.8 shows a numerical summary of grouped data from all the STORET and LASAR sites with more than one sample in the Necanicum River for the parameters under consideration in this assessment.

7.5.3 Other Data Sources

Necanicum River Watershed council members collected temperature data from various streams in the watershed using TidBit® temperature data loggers manufactured by Onset Computer Co. Temperature data loggers were installed at six sites in June and retrieved in October of 2000 and 2001. The six sites are listed in Table 7.9.

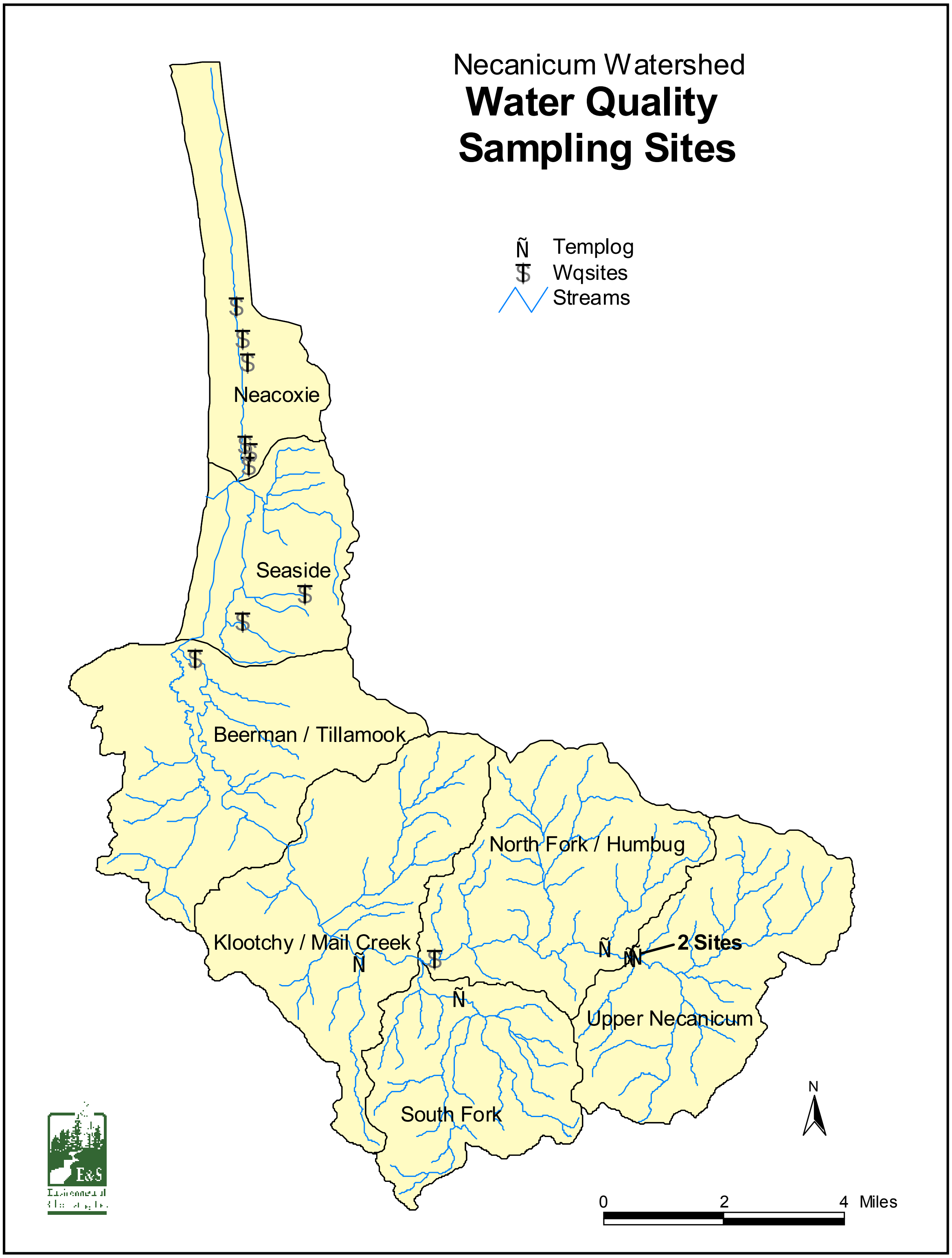


Figure 7.1. EPA STORET sampling sites in the Necanicum River watershed. Site descriptions are provided in Table 7.7.

Table 7.7. Ambient water quality sampling sites used for water quality assessment in the Necanicum River watershed (EPA 2000).

STORET ID	DEQ ID	Latitude	Longitude	Description	No. Samples	No. Analyses
	10803	46.02440	123.91560	Neacoxie Cr. At So.side Pacific Way Culvert	4	49
	10804	46.05760	123.92040	Neacoxie Cr. @ N.side E Gearhart Tlp.Rd.culvert.	4	29
	10805	46.04400	123.91580	Neacoxie Cr. @ So. Side of Surf Pine Rd. Bridge	4	30
	22935	45.89980	123.95540	Ecola Cr. Side Channel below Cannon Beach St	3	16
	22937	45.89990	123.95570	Ecola Cr. Side Channel 200 Ft West of Cannon Beach	3	20
	22941	45.89940	123.95240	Ecola Cr. At Hwy 101	3	19
	22949	45.89960	123.95500	Ecola Cr. Side Channel @ mouth, nr Cannon Beach	2	15
	22951	45.89960	123.95520	Ecola Cr. Side Channel 5 ft D/s Cannon Beach Stp	3	24
402191	10521	45.95250	123.92389	Necanicum River at Riverside Lake Camp (Seaside)	64	682
402480	10803	46.02250	123.91389	Neacoxie Cr. At So.side Pacific Way Culvert	4	70
402906	11226	45.90222	123.84278	Necanicum River at 12th Ave (Seaside)	12	28
405122	12367	46.04972	123.91806	Neacoxie Creek at So. Side Del Ray Beach Rd.	5	19
405123		46.01917	123.91417	Neacoxie Cr @ So. Side of G Street Culvert	2	16
405433	12649	45.98167	123.91389	Neawanna Cr.@ Jntn. Of Sunquist & Wahanna Rds.	2	25
405439	12654	45.98889	123.89278	Neawanna Cr. Tributary (Unnamed) at N-m Road	2	10
	22950	45.89960	123.95520	Ecola Cr. Side Channel 50 ft W of Cannon Beach	2	9

Note: Not all constituents were analyzed for every sample. The number of samples listed is the number of samples for which all or most of the constituents under consideration were analyzed.

Table 7.8. Numerical data summary for water quality parameters: Necanicum River Watershed water quality sampling sites.

Item Units	Dissolved Oxygen (mg/L)	*E. Coli* (No./100 mL)	Fecal coliform (No./100 mL)	Nitrate-N (mg/L)	pH (Units)	Temperature (Degrees C)	Total P (mg/L)	Turbidity (NTU)
Number of observations	119	71	118	138	128	151	85	142
Minimum	3.6	2	0	0.01	6	3	0.009	1
Maximum	12.7	630	2400	0.682	8.4	23	2.32	54
Mean	9.93	90.08	168.25	0.26	6.99	11.82	0.24	3.44
Std. dev.	1.98	130.70	285.98	0.16	0.30	4.09	0.52	5.94
1st quartile[1]	9.25	30.00	36.00	0.12	6.80	9.00	0.01	1.00
Median[2]	10.30	56.00	65.50	0.24	7.00	11.00	0.02	2.00
3rd quartile[3]	11.25	91.00	170.00	0.38	7.11	14.70	0.25	3.00

[1] 25% of values were less than or equal to the 1st quartile value
[2] 50% of values were less than or equal to the median value
[3] 75% of values were less than or equal to the 3rd quartile value

Table 7.9. TidBit sample sites in the Necanicum River watershed, summers of 2000 and 2001 .

Site	TidBit ID No.	Latitude	Longitude	Site Description
1	16097	45.89342	123.8339	South Fork Necanicum above diversion
2	16121	45.90101	123.8685	Mail Creek
3	16098	n.a.	n.a.	Beerman Creek
4	16111	45.90475	123.7753	Warner Creek 150 ft upstream of the river.
5	16103	45.90533	123.7735	Charlie Creek 200 ft upstream of the mouth of the creek
6	16092	45.90678	123.7842	Little Humbug Creek 200 ft downstream of the highway bridge

n.a. = not available

7.6 Water Quality Constituents

7.6.1 Temperature

Available temperature data from STORET and LASAR are shown in Figure 7.2. Of the 151 available temperature measurements, 10 (6.6 percent) exceed 17.8° C, and 56 (37 percent) exceed 12.8° C.

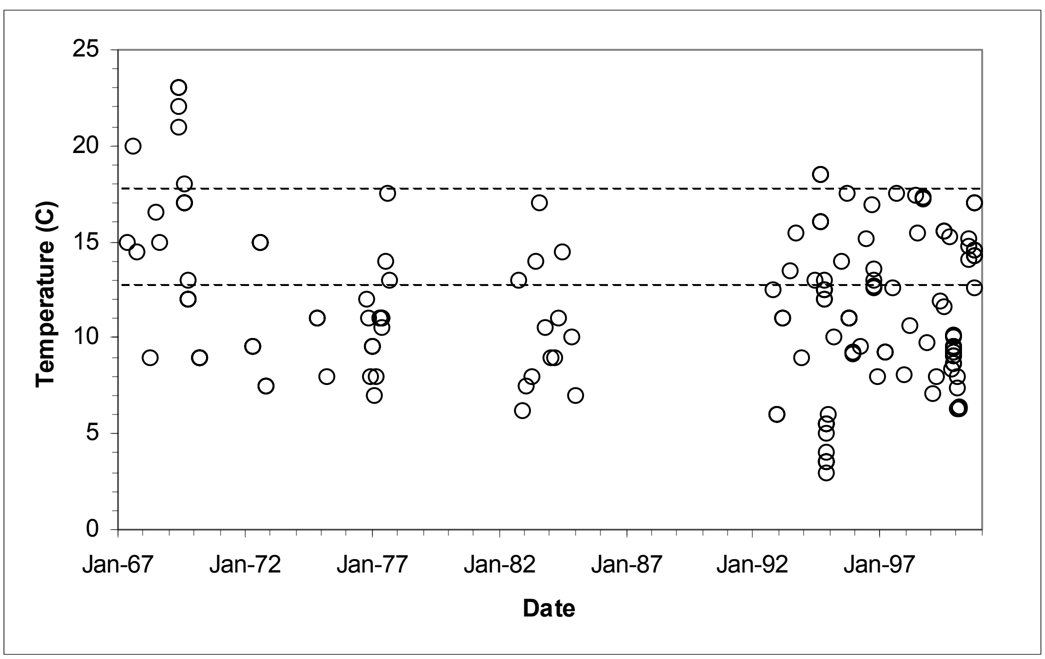


Figure 7.2. Temperature measurements taken in the Necanicum River basin 1967- 2000. The horizontal lines mark the screening criteria of 12.8° C and 17.8° C. (Data from STORET and LASAR)

Temperature loggers placed at several sites in the Necanicum River watershed collected temperature at intervals of between two to three hours between June and October of 2000 and 2001. Data have been statistically processed to yield the 7-day average of the daily maximum temperatures (commonly referred to the *7-day statistic*). These 7-day statistics are used to specify if the sampled stream temperatures violate State water quality standards. Figure 7.3 shows the 7-day statistic for the six sites in the Necanicum River watershed. Figure 7.4 shows a box plot[3] of the distribution of maximum daily temperature for each of the monitoring sites.

The general trend of temperature through the summer is similar at all sites, as would be expected, because water temperature is largely a function of sunlight and ambient air temperature. The 7-day mean maximum temperature did not exceed 17.8° C at any site at any time during the summer, but it did exceed 12.8° C (the ODEQ temperature criterion for salmonid spawning) at all sites during much of the summer.

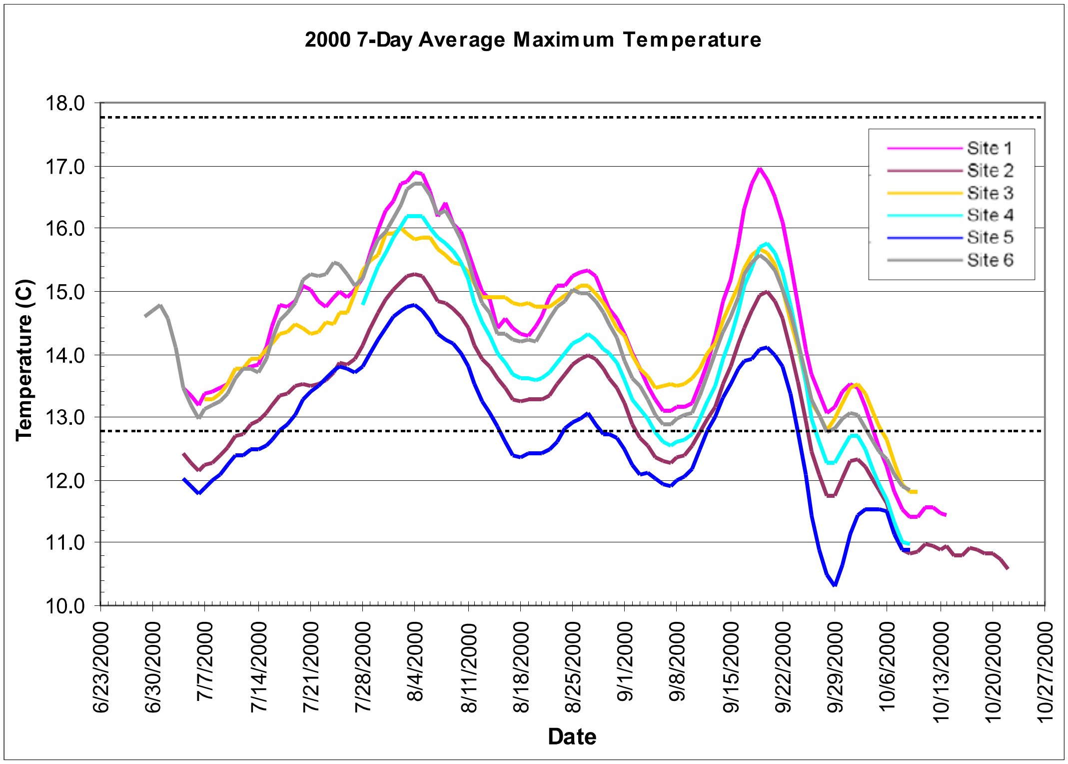
In both Figure 7.3 and Figure 7.4 it is evident that, even though the pattern is similar, there are distinct differences among the sites. Site 1, South Fork above the diversion, is the warmest site, while Site 5, Charlie Creek is the coolest. Site 2, Mail Creek, while generally warmer than Charlie Creek, is cooler than the rest of the sites. Site 3, Beerman Creek, Site 6, Little Humbug Creek, and Site 4, Warner Creek, are similar in both pattern and magnitude, falling intermediate between South Fork and Mail Creek.

These data suggest that the Necanicum River is not impaired for temperature relative to salmonid rearing and growth, but may be moderately impaired for salmonid spawning and incubation. Specific determination about impairment for salmonid depends on the periodicity of spawning activity.

7.6.2 Dissolved Oxygen

Dissolved oxygen data are presented in Figure 7.5. Of the 119 available dissolved oxygen measurements, 15 (12.6 percent) were below 8.0 mg/L, and 77 (64.7 percent) were below 11.0 mg/L. These data suggest that at least portions of the Necanicum River may be impaired with

[3] A box plot shows the distribution of the data. The solid line through the box shows the median, the dashed line the mean. The top and bottom of the box are at the 75th and 25th percentiles, respectively, so that the box includes the central 50 percent of the distribution. The whiskers extend to 1.5 times the interquartile distance above and below the box. Points beyond the whiskers are outliers. The extreme values of the distribution are represented by solid circles.



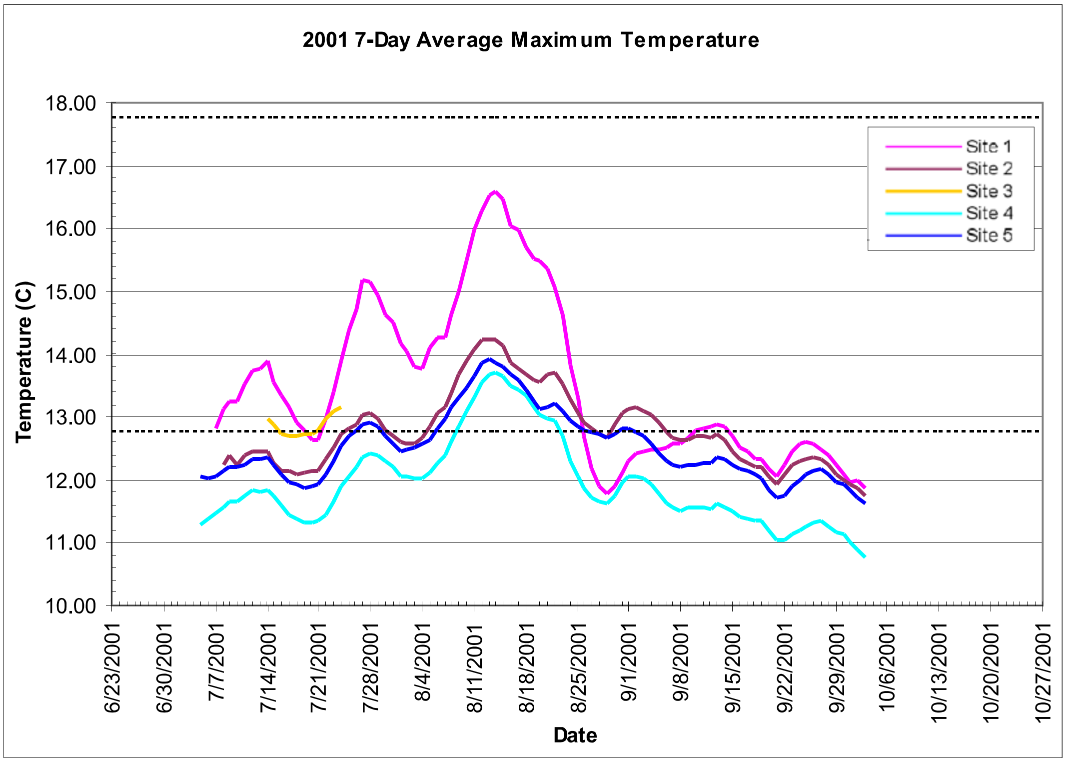


Figure 7.3. 7-day mean maximum daily temperature measured at six sites in the Necanicum River watershed during summer 2000 and at five sites during summer 2001. The horizontal dashed lines show the 12.8° C and 17.8° C criteria. Site locations are provided in Table 7.9. The monitor at site 6 malfunctioned during 2001.

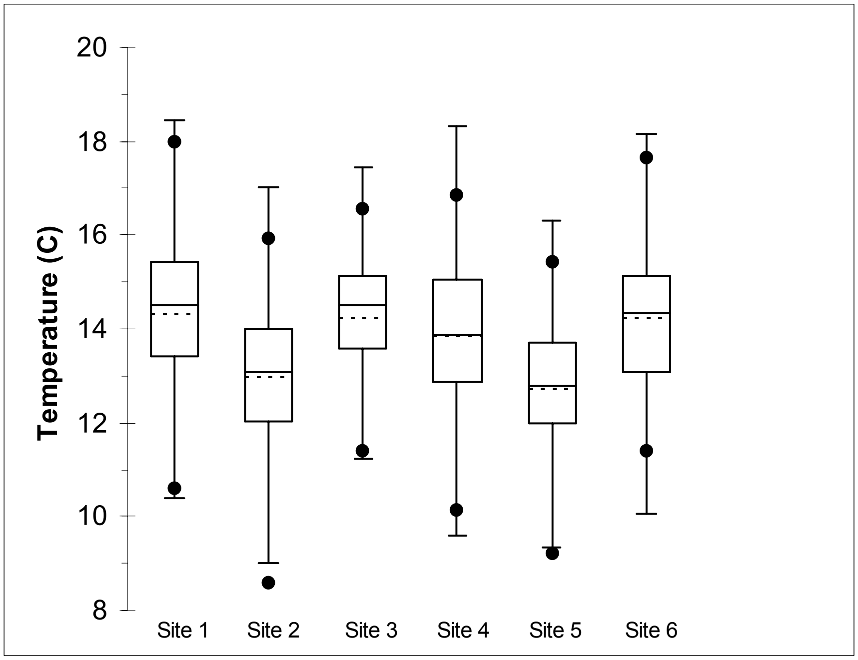


Figure 7.4. Box plot of maximum daily temperature measured at six sites in the Necanicum River watershed during June through October, 2000. Site locations are provided in Table 7.9.

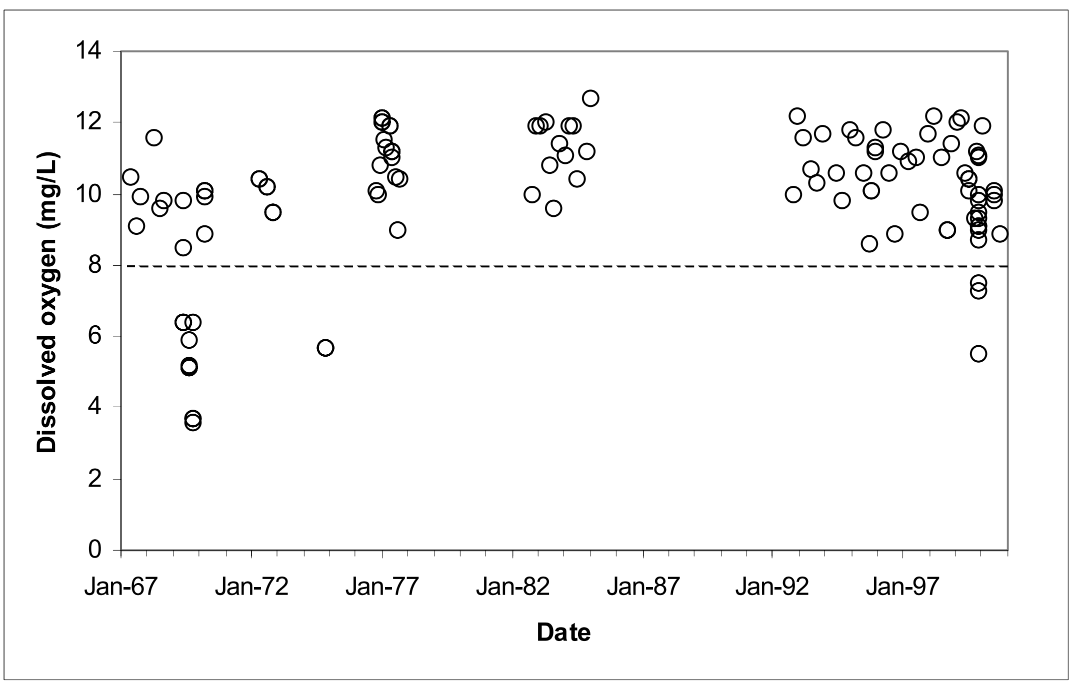


Figure 7.5. Dissolved oxygen measurements taken in the Necanicum River basin, 1967-2000. The horizontal line marks the screening criterion of 8.0 mg/L. (Data from STORET and LASAR)

respect to dissolved oxygen to support salmonid spawning and incubation, depending on the seasonality of spawning activity.

7.6.3 pH

Data for pH are presented in Figure 7.6. Only 3.1 percent of the 128 available measurements fall outside the range of the screening criteria. Based on these data, there is no reason to suspect that water quality in the Necanicum River is impaired for pH.

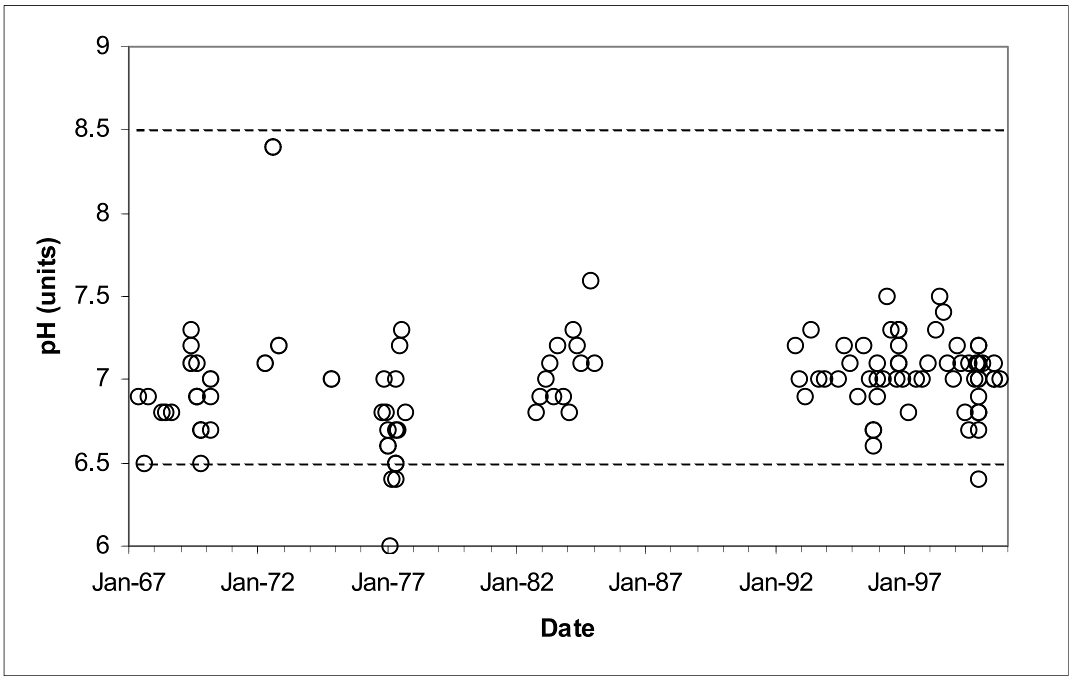


Figure 7.6. pH measurements taken in the Necanicum River basin, 1967-2000. The horizontal lines mark the screening criteria of 6.5 and 8.5. (Data from STORET and LASAR)

7.6.4 Nutrients

<u>Phosphorus</u>

Data for total phosphorus are presented in Figure 7.7. Of the 85 measurements for total phosphorus, 37 (43.5 percent) are greater than the screening criterion of 0.05 mg/L. These data suggest that the Necanicum River may be moderately impaired with respect to phosphorus.

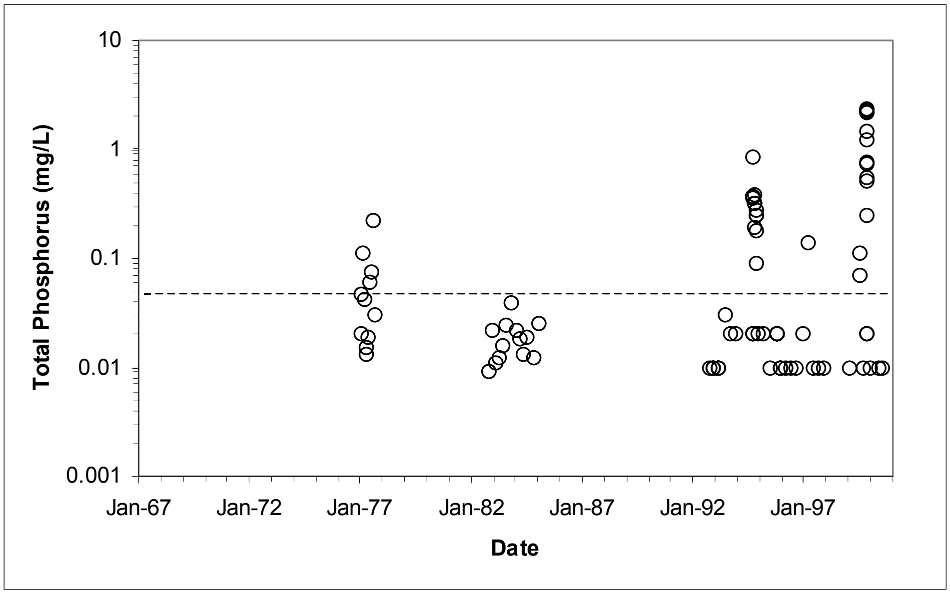


Figure 7.7. Total phosphorus measurements taken at all sites in the Necanicum River basin 1967-2000. The horizontal line marks the screening criterion of 0.05 mg/L total phosphorus (as P). (Data from STORET and LASAR)

A seasonal analysis of the STORET data from the Wilson River through 1995 conducted by ODEQ (Hinzman and Nelson 1998) showed that total phosphorus concentration in the Wilson River did not vary much seasonally. Sullivan et al. (1998) measured total phosphorus in the Wilson River during 1997. Total phosphorus concentrations were typically less than about 0.1 to 0.2 mg/L, except during storms when the concentrations sometimes exceeded 0.5 mg/L. Total phosphorus at the forest/ agriculture interface exhibited similar patterns, although concentrations were often somewhat lower than at the lower watershed sites.

Total phosphorus is closely related to total suspended solids (TSS) concentration, which suggests that the phosphorus is bound to soil particles. It is likely that the sources of the total phosphorus and TSS are the same and that the phosphorus is geologic in origin. Additionally, paired sample analyses on the Wilson River between RM 3.5 and the forest/agriculture interface site suggested that the contribution of total phosphorus from the agricultural parts of the watershed was minimal and that total phosphorus was mostly generated in the forested part of the watershed where most of the sediment originates.

These data suggest that, although the screening criterion of 0.05 mg/L is exceeded in the Necanicum River by more than 43 percent of the samples, the higher concentration of total phosphorus may not contribute to excess plant growth. Although the screening criteria require noting the Necanicum River to be moderately impaired with respect to phosphorus, further

investigation may be needed to determine if the relatively high concentrations are actually causing impairment.

Nitrogen

Data for total nitrate-nitrogen (NO_3-N) are presented in Figure 7.8. Of 138 measurements, 52 (37.7 percent) exceed the screening criterion of 0.3 mg/L. Based on this, the Necanicum River would be considered moderately impaired with respect to nitrogen. Recent work in the Wilson River watershed provides some insight into nitrogen dynamics in watersheds in the North Coast Basin.

A seasonal analysis of STORET data from the Wilson River through 1995 conducted by the Tillamook Bay National Estuary Program (TBNEP) (Hinzman and Nelson 1998) showed that nitrate-nitrogen concentration in the Wilson River varied seasonally. Nitrate-nitrogen was typically low, with median values less than 0.3mg/L, in the summer (Jun to Aug) with the highest concentrations occurring in November and December, at median values 0.65 and 0.75 mg/L respectively.

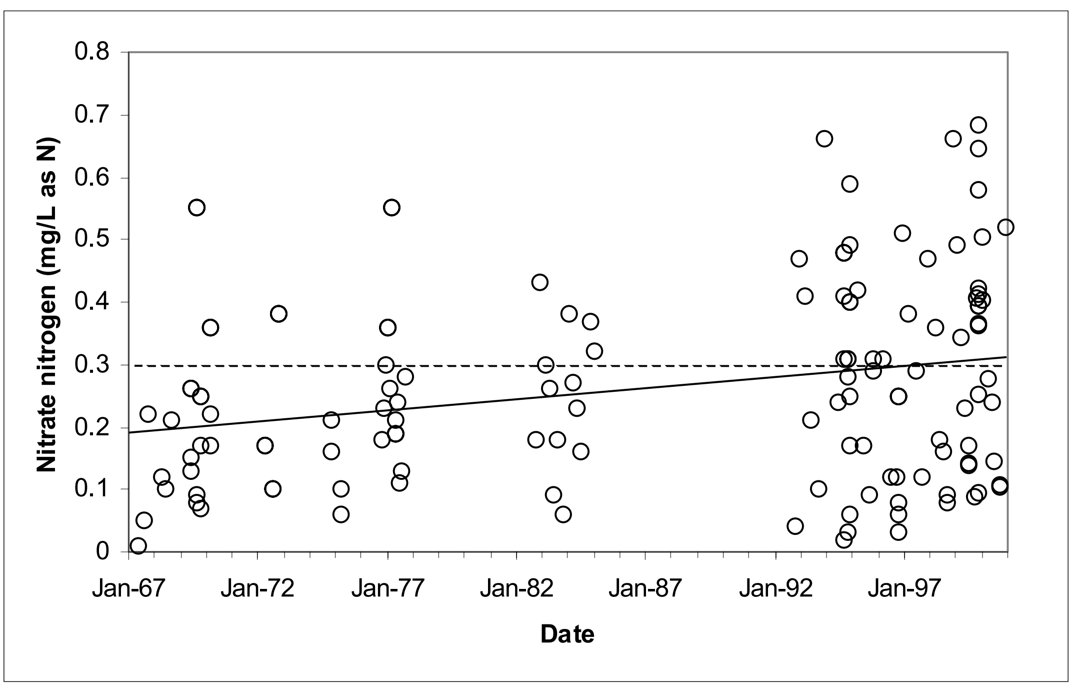


Figure 7.8. Nitrate nitrogen measured in the Necanicum River watershed 1967-2000. The horizontal dashed line marks the screening criterion of 0.3 mg/L. The solid line shows the linear regression of concentration vs. date. (Data from STORET and LASAR)

Sullivan et al. (1998) found that total inorganic nitrogen concentrations (TIN=nitrate (NO_3-N) + ammonia (NH_4-N)) were generally near 1 mg/L (± 0.2 mg/L) in the Wilson River. TIN was typically composed of more than 95 percent NO_3^-, with a very small NH_4^+ component. Limited data from the forest/agriculture interface sites showed similar patterns. Paired sample analyses (samples taken within a few hours of each other) between the primary and forest/agriculture interface sites showed there was little contribution of TIN to the rivers from the lower agricultural portions of the watershed.

Concentrations of TIN were reduced during the summer and were higher during the winter. This was likely due to greater biological demand for N in the aquatic and terrestrial systems during summer months. The greatest amount of seasonal variability in TIN loads occurred during the winter months, and may have been associated with the greater variability in winter flows. However, there was no clear relationship between TIN concentrations and flow.

Figure 7.8 suggests that nitrate concentration may be increasing in the Necanicum River. The cause of such an increase in nitrate can not be determined from the available data. It is possible that nitrogen fixation in large alder stands in the Necanicum River watershed that have developed subsequent to logging activities may be contributing to higher nitrogen concentration in the river (c.f. Stottlemyer 1992).

7.6.5 Bacteria

The Necanicum River is included on the 1998 ODEQ 303d list of water quality impaired water bodies for bacteria from the mouth to the headwaters. The bacteria water quality standard for recreational contact applies to both fresh and saline waters and is intended to protect people in contact with water, such as swimmers. The shellfish water quality standard is designed to protect people from pathogens which might be consumed with raw shellfish.

Data for bacteria in the Necanicum River are presented in Figures 7.9 (fecal coliform bacteria [FCB]) and 7.10 (*E. coli*). In unimpaired waters, not more than 50 percent of estuarine samples should exceed 14 fecal coliform bacteria per 100 mL, and not more than 10 percent should exceed 43 per 100 mL (shellfish standards). For the available data for FCB, 86.4 percent of the 118 measurements exceed 14 colony forming units (cfu) per 100 mL, and 70.3 percent exceed 43 cfu/100 mL. For *E. coli*, 18.7 percent of the 75 available measurements exceed 126 cfu/100 mL and 6.7 percent exceed the single sample maximum of 406 cfu/100 mL.

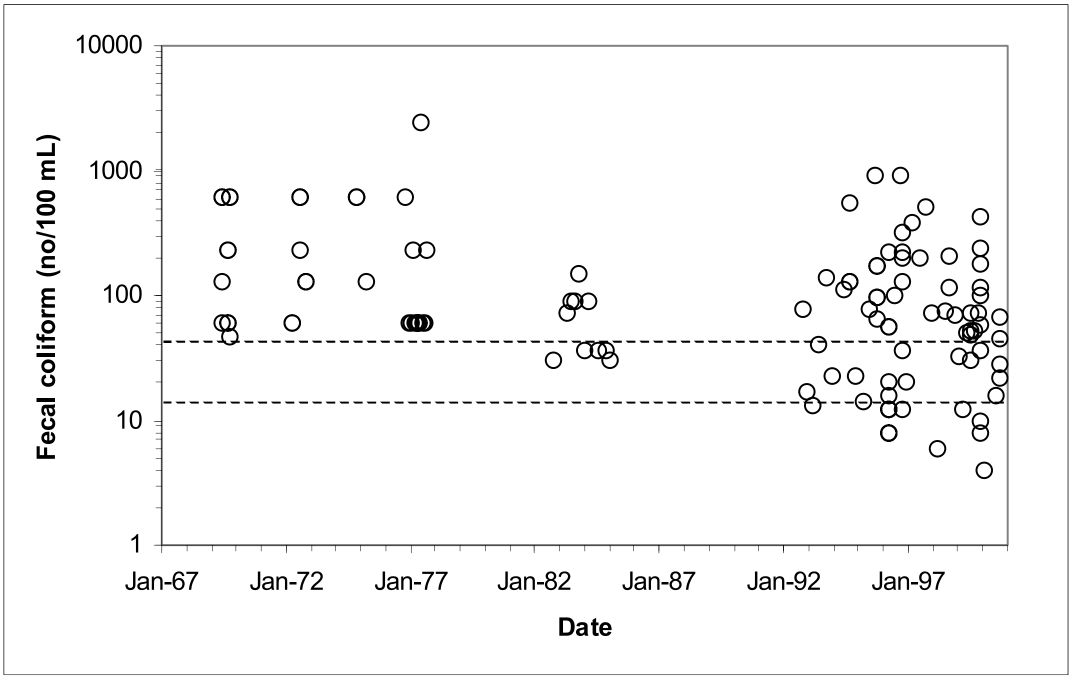


Figure 7.9. Log transformed fecal coliform bacteria measurements taken at all sites in the Necanicum River basin, 1967-2000. The horizontal lines mark the screening criteria of 14 and 43 colony forming units per 100 mL. (Data from STORET and LASAR)

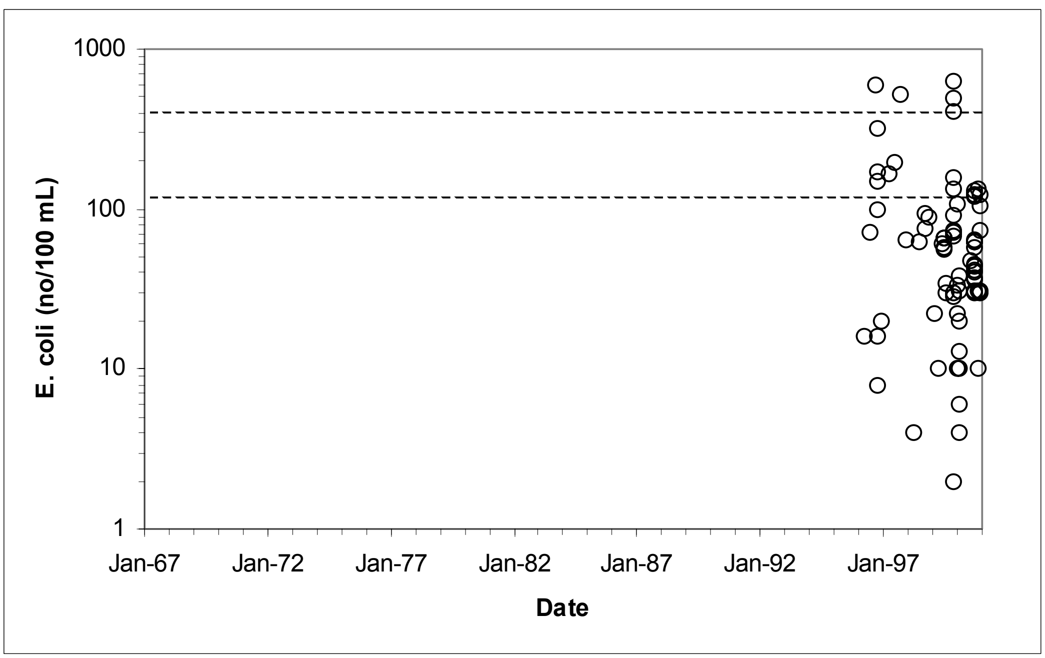


Figure 7.10. Log transformed E. coli measurements taken at all sites in the Necanicum River basin, 1967-2000. The horizontal lines mark the screening criteria of 26 and 406 cfu/mL. (Data from STORET and LASAR)

Based on the available data, water quality in the Necanicum River is impaired with respect to fecal coliform bacteria for shellfish production, and moderately impaired with respect to *E. coli* for water contact recreation.

7.6.6 Turbidity

Data for turbidity are presented in Figure 7.11. Only 1 of 142 measurements exceed the evaluation criterion of 50 NTU. This suggests that there is no impairment of water quality in regard to turbidity. However, it is likely that few of the samples considered in the assessment were taken during rainfall runoff events. It is probable, therefore that they do not represent the true range of values of turbidity. Additional sampling during rainfall events would be necessary to adequately evaluate water quality with regard to turbidity.

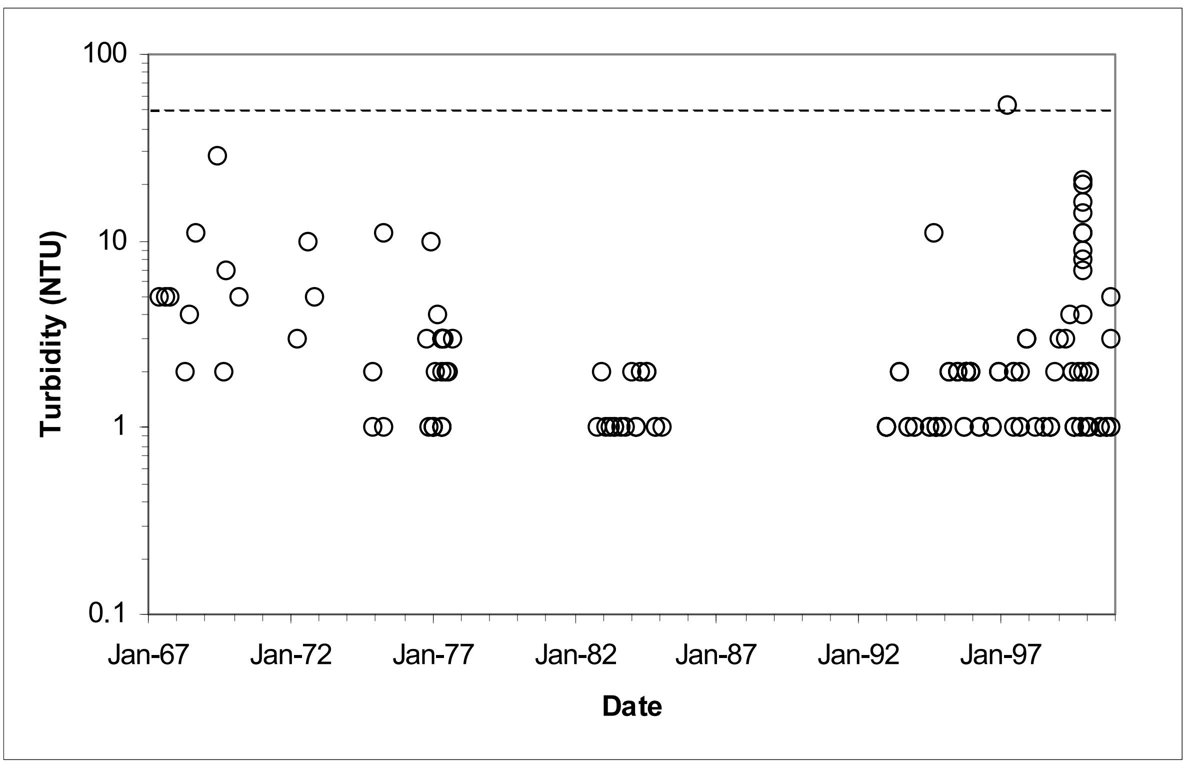


Figure 7.11. Turbidity measurements taken at all sites in the Necanicum River, 1967-2000. The horizontal line marks the screening criterion of 50 NTU. (Data from STORET and LASAR.)

7.6.7 Contaminants

From 1967 to 2000, nine sites in the Necanicum River watershed have been sampled and analyzed for one or more toxic metals. Of the 36 analyses, only one, a single sample for lead, had positive results greater than the detection limit and higher than the value for metals considered in our screening criteria. The results are shown in Table 7.10 and Figure 7.12. These results are not sufficient to determine whether or not the Necanicum River is impaired for trace metals. This is a data gap that could be filled by further sampling and analysis.

Table 7.10. Concentration of trace metals measured at various sites in the Necanicum River watershed 1967-2000. (Values in µg/L.)

Parameter	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Zinc (Zn)	Lead (Pb)
N	4	5	10	16	1
Minimum	0.11	0.23	0.3	0.66	0.31
Maximum	0.18	0.45	0.30	12.60	0.31
Mean	0.15	0.31	0.18	4.83	--
Criterion	0.40	11.00	0.36	32.70	0.05

On March 26, 1996 four sites (Table 7.11) in the Necanicum River watershed were sampled for a suite of 45 organic contaminants including pesticides and herbicides. None of the organic contaminants were present at any of the sites in quantities greater than the limit of quantitation of the analytical method. These results suggest that it is unlikely that the Necanicum River is impaired for organic contaminants.

Table 7.11. Sites in the Necanicum River watershed sampled for organic contaminants, 3/26/96.

STORET ID	DEQ ID	Latitude	Longitude	Description
	10803	46.02440	123.91560	Neacoxie Cr. @ S.side Pacific Way Culvert
	10804	46.05760	123.92040	Neacoxie Cr. @ N.side E. Gearhart Tlp.Rd.culvert
	10805	46.04400	123.91580	Neacoxie Cr. @ S. side of Surf Pine Rd. Br.
405122	12367	46.04972	123.91806	Neacoxie Cr. @ S. side Del Ray Beach Rd.

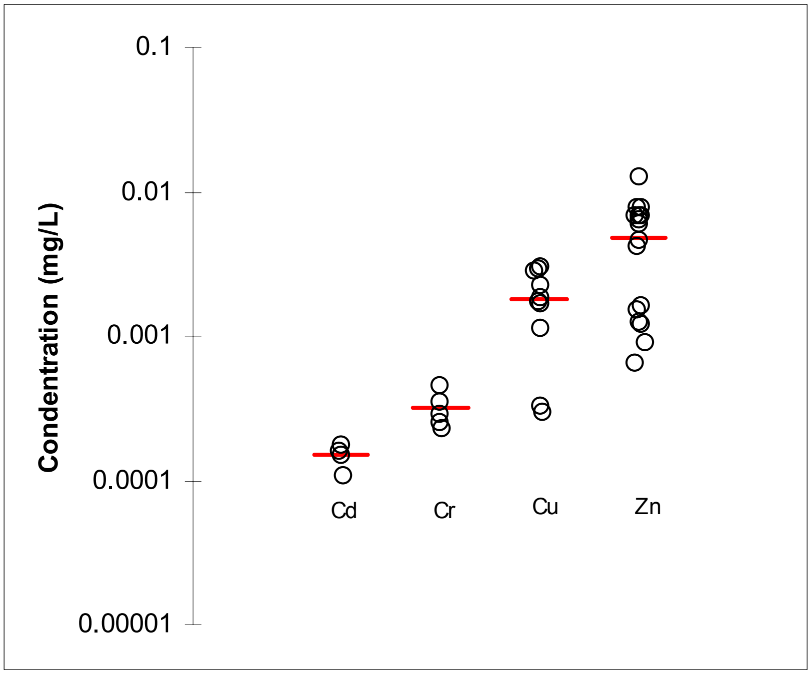


Figure 7.12. Scattergram of trace metal analysis from various sites in the Necanicum River watershed between 1967 and 2000. Short horizontal lines show the mean of values for each metal. (Data from STORET and LASAR)

7.7 Water Quality Conditions

At the screening level of this assessment, water quality in the major streams of the Necanicum River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for total phosphorus, nitrogen, and fecal coliform bacteria. Dissolved oxygen and temperature may also be a problem with respect to salmonid spawning and incubation. There is no reason to suspect that the river suffers from impairment with respect to pH, turbidity, or organic contaminants. There is not sufficient data to make a determination with respect to trace metals (Table 7.12).

Issues with regard to bacterial contamination could be addressed through development and implementation of a coordinated management plan. Temperature and dissolved oxygen issues can be addressed by stream and watershed restoration activities. In order to adequately address the causes of impairment with respect to nutrients and trace metals, additional data should be obtained through a carefully designed water quality monitoring program.

Table 7.12. Level of impairment found in the Necanicum River watershed based on Watershed Assessment screening criteria.

Constituent	Criterion	Number of Samples	Number Exceeding Criterion	Percent Exceeding Criterion	Impairment Status[1]
Temperature	12.8 C	151	56	37.0	M
	17.8 C		10	6.6	N
Dissolved Oxygen	11.0 mg/L	119	77	64.7	I
	8.0 mg/L		15	12.6	N
pH	6.5-8.5	128	4	3.1	N
Total Phosphorus	0.03 mg/L	85	37	43.5	M
Nitrate Nitrogen	0.5 mg/L	138	52	37.7	M
E. coli	126 /100 mL	75	14	18.7	M
	406/100 mL		5	6.7	N
Fecal coliform bacteria	14/100 mL	118	102	86.4	I
	43/100 mL		83	70.3	I
Turbidity	50 NTU	142	1	0.7	N
Organic contaminants	any detected	4	0	0	N
Metal contaminants	varies	36	1	2.8	NSF

[1]Impairment status: N = not impaired, M = moderately impaired, I = impaired, NSF=insufficient data.

CHAPTER 8. WATERSHED CONDITION SUMMARY

8.1 Introduction

Summarizing current conditions and data gaps within the watershed will help to identify how current and past resource management is impacting aquatic resources. This summarization can contribute to development of a decision-making framework for identifying key restoration activities that will improve water quality and aquatic habitats. Following is a summary of key findings and data gaps derived from the primary components of this watershed assessment, including fisheries, fish habitat, hydrology, water use, sediment sources, and water quality.

8.2 Important Fisheries

Fisheries within the Necanicum River watershed have undergone significant changes during the twentieth century. The types of fish present and their locations and abundance have been altered from historical conditions in the watershed. Arguably, the most significant activities to affect the fisheries during the last one hundred years have been habitat modifications, hatchery programs and harvest.

The National Marine Fisheries Service (NMFS) has listed as threatened, or is considering as candidates for listing, several anadromous fish species in the watershed (Table 8.1). Listing occurs for entire Evolutionarily Significant Units (ESU), defined as genetically or ecologically distinctive groups of Pacific salmon, steelhead, or sea-run cutthroat trout.

Necanicum River coho salmon, chum salmon, steelhead trout, and sea-run cutthroat trout populations all appear to be depressed. At least part of these species' decline can be attributed to recent changes in oceanic conditions that, since about 1975, have been less favorable for the coasts. Coho salmon have been particularly hard hit by the poor ocean conditions because they

Table 8.1. Status of anadromous fish occurring in the Necanicum River watershed.

Fish	ESU	Status
Coho	Oregon Coast	Threatened
Coastal Cutthroat	Oregon Coast	Candidate
Chum	Pacific Coast	Not Warranted
Chinook	Oregon Coast	Not Warranted
Steelhead	Oregon Coast	Candidate

* An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

rear off the northern California and Oregon coasts and do not migrate into the more productive waters of the Gulf of Alaska. Overharvesting of coho salmon when ocean conditions were poor exacerbated the problem. Harvest management has been changed recently to adjust for the poor ocean conditions.

Hatchery fish spawning with wild fish may have caused genetic problems for coho salmon, steelhead trout, and/or sea-run cutthroat trout in the Necanicum River Basin. Although many contributors to the observed decline of anadromous fisheries are well known, the interactions among the various contributing factors are poorly understood. Information gaps for salmonids in the freshwater environment include:

- scientifically designed long-term monitoring programs to measure changes in key habitat variables through time;
- biological measures of habitat condition such as smolt production, density of juveniles per unit area of rearing habitat, and benthic macroinvertebrate abundance; and
- understanding of the amount of genetic mixing that has occurred between hatchery and wild stocks.

Information gaps for salmonids in the estuarine environment include:

- information on the quantity or quality of juvenile salmonid rearing habitat in the estuary;
- information on present use of various major estuarine habitats by juvenile salmonids; and
- long-term monitoring designed to evaluate effects of changes in watershed inputs of sediment, plant nutrients, large woody debris, and toxic substances on estuarine habitat conditions and estuarine biological communities.

Little of the existing information on fisheries populations was developed from statistically designed sampling programs. Inferences regarding population status were often based on potentially biased data. This can be a serious problem, particularly if management decisions are based on what may be inaccurate information. It is important, therefore, that scientifically designed sampling schemes be built into any short-term or long-term sampling program used for the management of the valued resources of the Necanicum River Basin. In addition, reliable long-term monitoring data were generally not available. Without long-term data sets, it is impossible to evaluate trends through time or to separate out effects of natural phenomena from human-induced changes.

Finally, there have been no comprehensive studies relating the condition of the watershed to conditions in the estuary, especially with respect to important impacts on valued resources. Many of the changes that have taken place in the estuarine environment are likely caused by, or related closely to, disturbances in the watershed that have altered flow, sediment input rates, and water quality. Monitoring and research directed at linking conditions in the watershed to conditions in the estuary are lacking.

8.3 Hydrology and Water Use

8.3.1 Hydrology

Human activities in a watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and aquatic habitats. These types of changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. Some examples of human activities that can impact watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. The focus of the hydrologic analysis component of this assessment was to evaluate the potential impacts from land and water use on the hydrology of this watershed (WPN 1999). It is important to note, however, that this assessment only provides a screen for potential hydrologic impacts based on current activities in the watershed. Identifying and quantifying those activities that are actually affecting the hydrology of the watershed would require a more in-depth analysis and is beyond the scope of this assessment.

Screening for land management activities that may be affecting natural hydrologic conditions suggests that forest roads have little effect on current hydrologic regimes with regard to peak flows, but other hydrologic impacts may have occurred in response to the upland management and/or development in the valley bottoms. Rural residential roads were judged to cause moderate to high peak flow enhancement in most of the subwatersheds (Table 8.2), but occupy relatively little area. Therefore, their overall contribution to discharge should be minimal. The Necanicum River watershed has an extensive floodplain that occupies 7 percent of the watershed. There are substantial palustrine and estuarine wetlands in the lower watershed. Loss of historical flood plain acreage and land cover (such as wetlands, forested valley bottoms) have likely had minimal impact on hydrologic conditions in the watershed. The existing wetlands likely exert considerable control on watershed-scale hydrologic function. There is a

Table 8.2. Potential effects on peak flows from land use practices.

Subwatershed	Area (mi^2)	Forestry Impacts	Forest Road Impacts	Rural Residential Road Impacts*
Beerman/Tillamook	15.8	Low	Low	High
Klootchy/Mail Creek	15.3	Low	Low	High
Neacoxie	7.4	Low	Low	Low
North Fork/Humbug	13.7	Low	Low	Moderate
Seaside	8.3	Low	Low	Moderate
South Fork	9.9	Low	Low	High
Upper Necanicum	13.3	Low	Low	Moderate

* Rural residential roads were estimated to cause moderate to high impacts on peak flows within the areas where they occur. However, rural residential areas occupy less than 1% of all subwatersheds except Neacoxie (1.3%), and so the overall impact on watershed hydrology is expected to be small.

clear need for floodplain and wetland protection, and perhaps enhancement, to regulate flood attenuation and water storage.

8.3.2 Water Use

Water is withdrawn from both surface and subsurface water supplies within almost all of the watersheds in Oregon. Much of this water is withdrawn for beneficial uses, such as irrigation, municipal water supply, and stock watering. When water is removed from these stores, a certain percentage is lost through processes such as evapotranspiration. Water that is "consumed " through these processes does not return to the stream or aquifer, resulting in reduced in-stream flows, which can adversely affect aquatic communities that are dependent upon this water. In fact, the dewatering of streams has often been cited as one of the major reasons for salmonid declines in the state of Oregon.

The largest amount of water appropriated in the Necanicum River watershed is for domestic water use, especially in the South Fork Necanicum River subwatershed. During dry seasons, domestic water use may have deleterious effects on in-stream habitats by reducing flows.

Water availability was assessed by ranking subwatersheds according to their dewatering potential. Half of the water availability subwatersheds were judged to have moderate or high dewatering potential (Table 8.3), which is defined as the potential for large proportions of in-stream flows to be lost from the stream channel through consumptive use. The South Fork

Necanicum River was judged to have high dewatering potential, largely as a result of municipal withdrawals (Table 8.3). The Necanicum River was judged to have moderate dewatering potential.

Table 8.3. Dewatering potential and associated beneficial uses of water in the Necanicum River watershed.

Subwatershed	Fish Use[1]	Average Percent Withdrawn[2]	Dominant Water Use	Dewatering Potential[3]
Necanicum River @ mouth	C, FC, WS, CH	23.8	Irrigation/ Agricultural	Moderate
Necanicum River above Klootchy Creek	C, FC, WS, CH	21.8	--	Moderate
Bergsvik Creek @ mouth	C, WS	0.0	Fish/Wildlife	Low
NF Necanicum River @ mouth	C, FC, WS	0.0	Municipal/ Domestic	Low
SF Necanicum River @ mouth	C, FC, WS	82.0	Municipal/ Domestic	High
Klootchy Creek @ mouth	C, FC, WS, CH	0.0	--	Low

1 C=coho, FC=fall chinook, WS=winter steelhead, CH=chum
2 Average of low flow months (June, July, August, September, October).
3 Greater than 30% is high, 10 to 30% is moderate, and less than 10% is low.

Based on current water availability model outputs, there appears to be significant concern for dewatering in the Necanicum River watershed. Three of the subwatersheds demonstrated water loss greater than 20 percent of the predicted in-stream flows. In the South Fork Necanicum River, dewatering potential exceeded 100 percent of flows one out of every two years. It is likely that water withdrawals from the Necanicum River and its tributaries may be having a large impact on current flows during periods of low flow.

Assuming that the in-stream water right for fish and wildlife is a good indicator of habitat conditions for salmonids, there is a potential for low flow conditions to have a deleterious effect on local salmonid populations. Consequently, any out-of-stream water use during these low flow situations will only exacerbate habitat problems. In-stream flow requirements for salmonids should be further evaluated to determine actual impacts of surface water withdrawals on salmonid populations. It is our recommendation that in-stream water rights continue to be protected and flows monitored during very low flow conditions.

8.4 Aquatic Habitats

Distribution and abundance of salmonids within a given watershed vary with habitat condition, such as substrate and pool frequency, and biological factors such as food distribution (i.e. insects and algae). In addition, salmonids have complex life histories and use different areas of the watershed during different parts of their life cycle. For example, salmonids need gravel substrates for spawning but may move to different stream segments during rearing. The interactions of these factors in space and time make it difficult to determine specific factors affecting salmonid populations. Consequently, entire watersheds, not just individual components, must be managed to maintain fish habitats (Garono and Brophy 1999).

The Endangered Species Act requires that all lands providing habitat for endangered species must be protected (Tuchmann et al. 1996). An understanding of the land patterns associated with the distribution of threatened and endangered species can lead to a better understanding of how to conserve these species. The OWEB process focuses primarily on salmonid habitat in the watershed. It is assumed, however, that other species will also benefit.

For all of the salmonid species that are found in the watershed, habitat conditions appear to be degraded. One of the biggest habitat-related problems in the watershed is the general lack of LWD. Other major problems identified were the general lack of channel complexity and off-channel habitat. The poor ratings for LWD recruitment from riparian areas indicate that recovery of habitat complexity in many areas will be a long process due to the lag time required to reestablish conifer communities in the riparian zone. Better management practices have eliminated a number of the man-caused disturbances that have contributed to the present condition of the freshwater habitat. A watershed approach to stream habitat restoration is needed to ensure continued recovery.

8.4.1 Fish Passage

Culverts can pose several types of fish passage problems, including excess height, excessive water velocity, insufficient water depth in culvert, disorienting flow patterns, and lack of resting pools between culverts. In some cases, culverts limit fish passage during only certain parts of the species' life cycle. For example, a culvert may be passable to larger adult anadromous fish and not juveniles. Culverts may also act as passage barriers only during particular environmental conditions such as high flow or low flow events. Because of these variable

effects, it is important to understand the interactions between habitat conditions and life stage for anadromous fish.

Only 23 culverts in the Necanicum River watershed have been surveyed by ODFW to determine fish passage characteristics. Of those surveyed, however, 69 percent were judged to be impassable (Table 8.4).

Table 8.4. Fish passage conditions in the Necanicum River watershed.

Subwatershed	Stream Length (mi)	Fish Use[1]	Miles Salmonid Use	# Known Impassable Culverts	# Road/ Stream Crossings
Beerman / Tillamook	24	C, FC, WS, CH	19.2	4	60
Klootchy / Mail Creek	27	C, FC, WS, CH	13.9	1	40
Neacoxie	7	C	0.7	0	6
North Fork / Humbug	31	C, FC, WS	10.5	1	45
Seaside	19	C, FC, WS, CH	11.4	2	35
South Fork	27	C, FC, WS	6.3	0	43
Upper Necanicum	27	C, FC, WS	12.5	8	40

[1] C=coho, FC=fall chinook, WS=winter steelhead, CH=chum

8.4.2 Fish Habitats

Understanding the spatial and temporal distribution of key aquatic habitat components is the first step in learning to maintain conditions suitable to sustain salmonid populations. These components must then be linked to larger scale watershed processes that may control them. For example, a stream that lacks sufficient LWD often has poor LWD recruitment potential in the riparian areas of that stream. By identifying this linkage, riparian areas can be managed to include more conifers to increase LWD recruitment potential. Also, high stream temperatures can often be linked to lack of shade as a result of poorly vegetated riparian areas. By linking actual conditions to current watershed-level processes, land mangers can better understand how to manage the resources to maintain these key aquatic habitat components.

Stream Morphology

Pools are important features for salmonids, providing refugia and feeding areas. Substrate is also an important channel feature since salmonids use gravel beds for spawning. Gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat quality. For streams that were surveyed, stream morphology and substrate

were compared with ODFW benchmarks to evaluate current habitat conditions. In the streams surveyed, pool conditions were generally moderate and gravel conditions were generally desirable (Table 8.5).

Table 8.5 Stream morphologic conditions in the Necanicum River watershed. Data were collected by ODFW (1990-1995).

Subwatershed	Stream Miles	Fish Use[1]	Miles Surveyed [2]	Pool Frequency[2]	Percent Pools[2]	Residual Pool Depth[2]	Gravel[2]
Beerman / Tillamook	24	C, FC, WS, CH	7.6 (7)	Moderate (4)	Desirable (4)	Moderate (7)	Desirable (5)
Klootchy / Mail Creek	27	C, FC, WS, CH	6.6 (7)	Moderate (5)	Moderate (6)	Desirable (5)	Desirable (5)
Neacoxie	7	C	--	--	--	--	--
North Fork / Humbug	31	C, FC, WS	3.7 (6)	Moderate (2)	Moderate (3)	Moderate (3)	Desirable (3)
Seaside	19	C, FC, WS, CH	--	--	--	--	--
South Fork	27	C, FC, WS	5.1 (6)	Moderate (4)	Moderate (3)	Moderate (4)	Moderate (5)
Upper Necanicum	27	C, FC, WS	8.6 (8)	Desirable (4)	Moderate (5)	Moderate (6)	Desirable (6)

[1] C=coho, FC=fall chinook, WS=winter steelhead, CH=chum
[2] Number in parentheses is the number of reaches in that category from ODFW surveys.

Large Woody Debris

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000, BLM 1996). LWD conditions were poor throughout the watershed, as was LWD recruitment potential (Table 8.6).

Wetlands

Wetlands contribute critical functions to watershed health, such as water quality improvement, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat (Mitsch and Gosselink 1993). Because of the importance of these functions, wetlands are

Table 8.6 Riparian and in-stream LWD conditions in the Necanicum River watershed.

Subwatershed	Str Length (mi)	Salmonid Use[1]	Riparian Recruitment[2]	Riparian Shade[2]	In-stream LWD[3]		
					Pieces	Volume	Key Pieces
Beerman / Tillamook	24	C, FC, WS, CH	low	high	Poor (7)	Poor (6)	Poor (7)
Klootchy / Mail Creek	27	C, FC, WS, CH	low	high	Poor (5)	Poor (6)	Poor (7)
Neacoxie	7	C	mod	low	-	-	-
North Fork / Humbug	31	C, FC, WS	low	high	Poor (3)	Poor (3)	Poor (4)
Seaside	19	C, FC, WS, CH	low	high	-	-	-
South Fork	27	C, FC, WS	low	high	Poor (3)	Poor (5)	Poor (3)
Upper Necanicum	27	C, FC, WS	low	high	Poor (5)	Poor (6)	Poor (8)

1 C=coho, FC=fall chinook, WS=winter steelhead, SS=summer steelhead, SC=spring chinook, CH=chum
2 From aerial photo interpretation by E&S Environmental Chemistry, Inc.
3 Subwatersheds were assigned categories (good, moderate, poor) based on the most prevalent category among all reaches surveyed in that subwatershed. The categories were based on how the data compared to ODFW habitat benchmarks. Number in parentheses is the number of reaches in that category.

regulated by both State and Federal agencies. Additionally, wetlands play an important role in the life cycles of salmonids (Lebovitz 1992). Estuarine wetlands provide holding and feeding areas for salmon smolts migrating out to the ocean. These estuarine wetlands also provide an acclimation area for smolts while they are adapting to the marine environment. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate. Wetlands provide cover and food in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream.

Estuarine wetlands and, in particular, palustrine wetlands are common landscape features in the Necanicum River watershed, especially along the mainstem river and in the Neacoxie and Seaside subwatersheds. Existing wetlands currently accessible to salmonids should be protected or restored. Those wetlands disconnected by hydrological modifications should be evaluated for potential reconnection and restoration.

8.5 Sediment Sources

Sediment in the rivers and streams of the Necanicum River watershed is an issue of concern. The combination of the wet climate, steep slopes in the uplands, and erosive soils results in naturally high levels of sediment in the rivers and streams. Historic wildfires in the watershed, as well as resource management practices over the past century are associated with an additional increase in sediment levels. High levels of sediment in the streams have been associated with

declining health of salmonid populations. While naturally occurring sources of sediment in the watershed may be uncontrollable (and perhaps to some degree beneficial), the additional sediment contributed by human activity can, in some cases, contribute to habitat degradation.

In this watershed, slope instability, road instability, rural road runoff, and streambank erosion are significant sediment sources (Table 8.7). Slope instability contributes to shallow landslides and deep-seated slumps, which are known to be common in the Oregon Coast Range. Streamside landslides and slumps can be major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed, and some forest roads are present on steep slopes. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of roads, especially unpaved gravel and dirt roads, indicates a significant potential for sediment contribution to the stream network. However, few roads are both in close proximity to a stream and situated on a steep slope. It is therefore unlikely that roads contribute an excessive amount of sediment to streams in this watershed.

Table 8.7. Potential sediment source conditions in the Necanicum River watershed.

Subwatershed	Area (sq. mi.)	Slope Instability[1]	Road Instability	Road Runoff	Stream Bank Erosion[2]
Beerman/Tillamook	15.8	High	Insufficient Data	Insufficient Data	High
Klootchy/Mail Creek	15.3	High	Insufficient Data	Insufficient Data	Moderate
Neacoxie	7.4	Low	Insufficient Data	Insufficient Data	Insufficient Data
North Fork/Humbug	13.7	High	Insufficient Data	Insufficient Data	Moderate
Seaside	8.3	Low	Insufficient Data	Insufficient Data	Insufficient Data
South Fork	9.9	High	Insufficient Data	Insufficient Data	Moderate
Upper Necanicum	13.3	Moderate	Insufficient Data	Insufficient Data	Moderate

[1] High was >20% area in high and moderate categories from ODF slope instability analysis. Moderate was 10 to 20% and low was < 10%.
[2] Based on percentage of surveyed stream length experiencing erosion.
0-25% = Low; 25-50% = Moderate; 100% = High

8.6 Water Quality

Water quality is controlled by the interaction of natural and human processes in the watershed. Processes that occur on the hillslope can ultimately control in-stream water quality. Pollutants are mobilized through surface and subsurface runoff and can cause degradation of stream water quality for both human use and fish habitat. Consequently, many water quality

parameters are highly episodic in nature and often associated with certain land use practices. The water quality assessment is based on a process that identifies the beneficial use of water, identifies the criteria that protect these benefits, and evaluates the current water quality conditions using these criteria as a rule set (WPN 1999).

Comparing minimum seasonal Oregon Water Quality Index (OWQI) values, water quality in the Necanicum River ranges from good to excellent according to OWQI, and generally as good as, or better than, water quality in other near-by rivers. Water quality data are collected by the ODEQ for the Necanicum River at Seaside as part of their ambient water quality network. In addition, STORET contains water quality monitoring data for 16 sites in the watershed that have been sampled more than once since 1966.

Major tributaries were sampled for temperature during the summers of 2000 and 2001 by the watershed council. Temperature data have been statistically processed to yield the 7-day average of the daily maximum temperatures (commonly referred to the *7-day statistic*). These 7-day statistics are used to specify if the sampled stream temperatures violate State water quality standards. Based on these data, none of the tributaries appear to be temperature limited for salmonid rearing and growth, but may be moderately impaired for salmonid spawning and incubation. In summer months, the various tributaries reach stream temperatures in the range of about 14^{o}to 17^{o} C.

At the screening level of this assessment, water quality in the major streams of the Necanicum River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, nitrogen, total phosphorus, and bacteria. Dissolved oxygen may also be a problem with respect to salmonid spawning and incubation. There is no reason to suspect that the river suffers from impairment with respect to pH, turbidity, or trace metals. There are not sufficient data to make a preliminary judgement with respect to organic contaminants. It should be noted, however, that available water quality data are not adequate for water quality characterization in this watershed, especially with respect to spatial variability and the response of parameters that tend to be episodic in nature, such as bacteria, turbidity, and total phosphorus.

CHAPTER 9. RECOMMENDATIONS

General

- Prioritize restoration and watershed management activities based on information in this assessment and any other assessment work conducted in the watershed. Prioritize areas with known salmonid use for both spawning and rearing. Focus on areas with sufficient water quality for salmonids (low temperature) and areas with relatively good stream channel characteristics (responsive channel habitat type, good geomorphologic conditions, and good riparian shade).

- Maintain relationships and contacts among the watershed council, the county, the city of Seaside and private timber owners to keep up-to-date on data collection, further assessment, and restoration activities in the watershed. Update assessment data sets periodically.

Data

- Use a standardized base map. As a part of this assessment, a series of 1:24,000 base map layers were developed. We recommend that these layers be used as a base map and additional data be maintained at a scale of 1:24,000 or larger (i.e. 1:12,000). All of these layers will relate directly to the USGS 7.5 minute quadrangles which can be used to develop additional data layers and find locations in the field.

- Georeference all field data at a scale of 1:24,000 or better. This can be accomplished by using GPS to record latitude and longitude or by marking the location on the USGS quadrangle maps.

- Maintain data in an accessible location and format. The watershed council would be the best place for this. Most data should be maintained in a GIS format and updated annually. Some coverages will be updated periodically by the agency that created the coverage (i.e. salmonid distribution data from ODFW). These data sets should be kept current in the database.

- Collect additional data in priority areas. The decision-making framework provided by this document allows the user to select strategic locations for data collection based on features such as channel habitat type, known salmonid distribution, land use, and water quality conditions.

- Get expert advice on data collection and processing. Consult with the Technical Advisory Committee, federal and state agencies, and consultants to develop appropriate sampling collection, quality control, and data analysis protocols.

- Evaluate and ground-truth the GIS data layers. Several of the data sets used to develop this assessment need to be evaluated and compared to on-the-ground conditions before restoration actions are taken or final conclusions are made about ecosystem processes. Layers that need further evaluation or updating include, in particular, land use, roads, channel habitat types, wetlands, and riparian vegetation and shade.

- Refine the land use layer. Continue to develop the land use layer to reflect changes in land use. Update the layer with digital National Wetlands Inventory data as they become available.

Fisheries

- Develop and update a fish limits coverage, in cooperation with ODFW.

- Efforts to inventory anadromous salmonid habitat throughout the watershed should continue.

- Work with ODFW to identify viable populations and distributions of sensitive species, particularly salmonids. These data are critical in developing watershed enhancement strategies.

- Identify and survey areas currently used by salmonids. Collect stream survey data according to ODFW protocols. These data will help identify habitat limitations and areas that may provide good habitat but are currently blocked by a barrier.

Aquatic Habitats

- Field verify the channel habitat type GIS data layer.

- Field verify the riparian GIS data layers.

- Areas of good habitat should be identified and protected. This should include an analysis of the watershed upstream from the good habitat to locate potential problems that could result in future degradation of the habitat.

- Where feasible, habitat should be improved through the creation of off-channel winter refugia and introduction of LWD. Efforts should focus first on locations where the target fish species are known to be present.

- Long-term monitoring in the watershed is needed to evaluate changes in habitat and system productivity for juvenile salmonids through time. One approach might be to select representative reaches in upper, mid, and lower sections of the major subwatersheds as monitoring sites. Parameters to monitor would need to be carefully selected to provide the most information with the least expenditure of time and money.

- In the estuary, information is needed on the relative importance of major habitat types to the various anadromous salmonid species. This could be accomplished through focused sampling of specific habitat types when the various salmonid species are present.

- Integrated long-term monitoring should be designed to provide the data needed to test hypotheses regarding the effects of changes in estuarine conditions on juvenile salmonid rearing habitat in the estuary.

- Develop quantitative or semi-quantitative measures of estuarine habitat quality — similar to those used in the freshwater environment to classify stream habitat — to help in the monitoring of long-term trends in estuarine habitat quality.

- Prioritize stream reaches for restoration of riparian vegetation. Start in areas currently used by salmonids and lacking in LWD recruitment potential, good shade conditions, or in-stream LWD.

- Plant riparian conifers and native species in areas lacking LWD recruitment potential. Start in areas of known salmonid use, and use the riparian vegetation map provided with this assessment and ODFW stream surveys to identify candidate reaches. Before any reaches are targeted for planting, they should be field verified for actual conditions and suitability. Vegetation planting should use only native species and mimic comparable undisturbed sites.

- Work with private industrial landowners to obtain available information regarding culverts and fish passage.

- Complete a culvert survey of all culverts that have not been evaluated for fish passage. Data should be maintained in a GIS. The road/stream crossing coverage is a good place to start. The culvert survey should begin in priority subwatersheds at the mouth of each of the streams. Establish priorities for culvert replacement.

- Replace priority culverts identified in the culvert survey.

- Install fish passages at known fish passage barriers that are caused by human influences.

- Prioritize estuarine wetlands for restoration, protection, or maintenance based on their value to salmonids and other fish and wildlife. Landowners with priority wetlands can then be contacted for possible wetland restoration.

- Prioritize for restoration, protection, or maintenance, palustrine wetlands that are connected to streams and provide back water rearing areas for salmonids. Start in areas with known salmonid rearing and spawning habitat.
- Identify and protect high-quality floodplain vegetative communities.

- Restore floodplain vegetation in priority lowland restoration areas.

- Educate the public about the historic function of the rivers and their floodplains.

Hydrology and Water Use

- Update and refine the roads layer. Keep in contact with land owners as the roads layer is updated to evaluate its accuracy.

- Develop an outreach program to encourage water conservation. Educate the public about dewatering effects and how water conservation will help salmonids in the watersheds.

- Identify water rights that are not currently in use and that may be available for in-stream water rights through leasing or conversion.

Sediment

- Identify roads that have not been surveyed for current conditions and fill these data gaps. Work with ODF to develop road survey methodologies.
- Map road failures in areas where data are lacking. Coordinate with watershed stakeholders that are currently collecting road data, such as private timber companies. Develop a strategy to fill in the data gaps.
- Map culvert locations and conditions in conjunction with the culvert survey conducted for fish passage barriers. Check with ODF, ODFW, and local foresters for the best methodologies and data to collect.
- Map all debris flows and landslides. Begin in the areas most susceptible to landslide activity.
- Where possible, conduct road restoration activities such as road reconstruction, decommissioning, and obliteration.
- Replace undersized culverts that are at risk of washing out. Prioritize these culverts from the culvert surveys.

Water Quality

- Develop a comprehensive water quality monitoring plan, in conjunction with ODEQ and private water quality experts.
- Conduct a water quality characterization study to determine the spatial and temporal patterns in water quality within the watershed.
- Based on the water quality monitoring plan and the results of the characterization study, develop and implement a systematic water quality monitoring program that includes routine monitoring and targeted monitoring of areas with high priority for restoration activity. Where appropriate, focus the water quality monitoring on constituents that are important for the specific area being restored. Use the water quality data to refine the restoration plans.
- Develop a continuous temperature monitoring network with monitors at strategically located points such as the mouths of tributary streams, locations of known spawning beds, at the interface between major land use types, or downstream of activities with the potential to influence water temperature.

- Include a plan for long-term monitoring in any restoration plan to measure the effects of the restoration activity.

- Begin to develop the capacity within the watershed council to conduct high quality, long term water quality monitoring to document the success of restoration activities.

- Locate and map potential sources of nitrogen, phosphorus, turbidity, and bacteria in the watershed.

- Conduct all water quality monitoring activities according to established guidelines such as those published by the Oregon Plan for Salmon and Watersheds or EPA.

- Cooperate with DEQ and other agencies to share data and expertise. Coordinate the council's monitoring activities with those of the agencies, including DEQ's efforts to develop Total Maximum Daily Loads for water quality limited stream segments.

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